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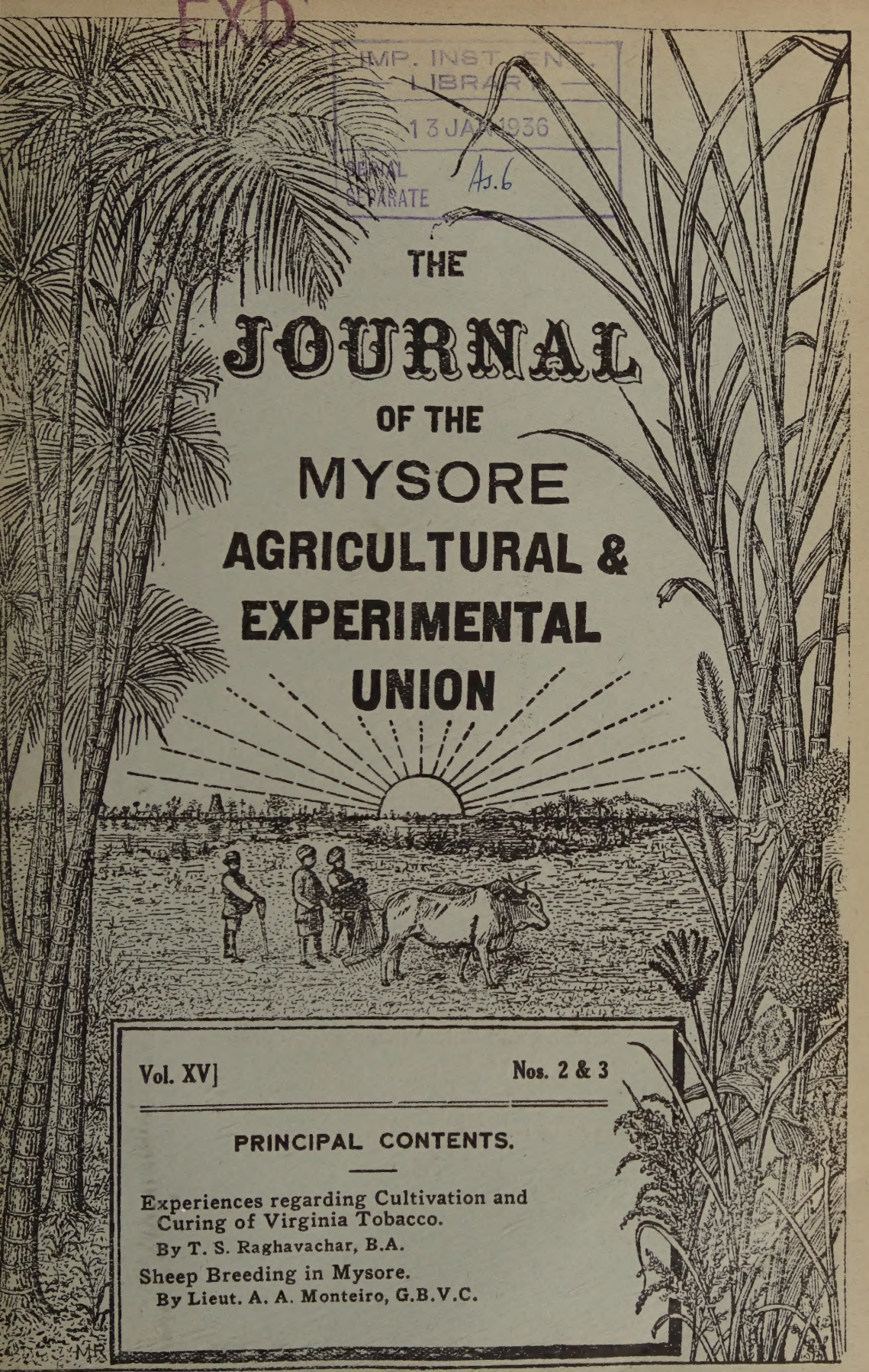

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By T. S. Raghavachar, B.A.

Sheep Breeding in Mysore.
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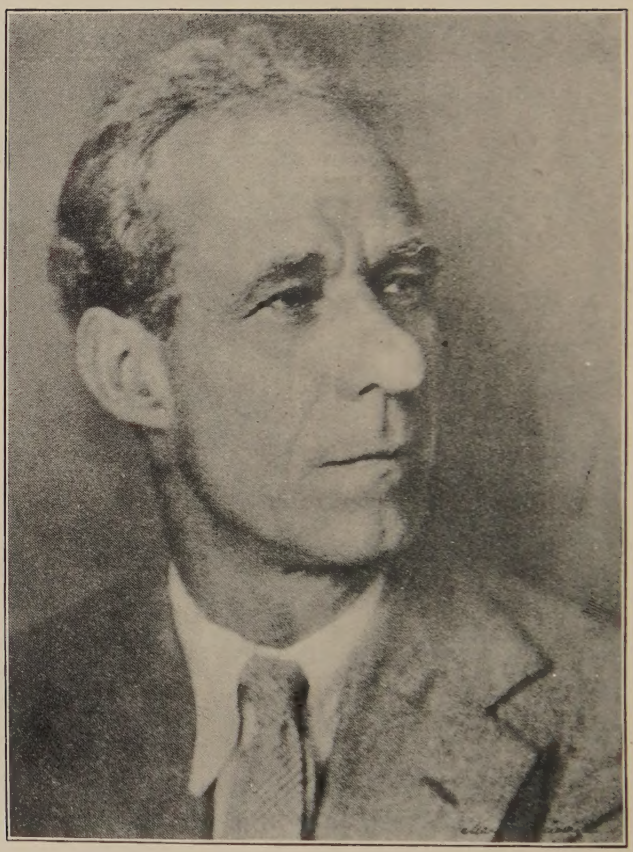


Dr. Leslie C. Coleman, M.A., Ph.D., C.I.E.

The Journal
of the
Mysore Agricultural
and
Experimental Union

Vol. XV] [Nos. 2 & 3

Dr. Leslie C. Coleman, C.I.E., M.A., Ph.D.
An Appreciation

By

Sir T. Vijaya Raghavachari

Dr. Coleman was born near Toronto on the 16th of June 1878 and was educated at the University of Toronto, where he obtained the degree of M.A. in 1905, winning the Governor-General's Gold Medal. Subsequently, he studied at Gottingen and took the degree of Ph.D. in 1907, having specialized in plant pathology. He joined the service of the Mysore State in 1908 and until 1913 held the post of the State Entomologist and Mycologist in Mysore. On the retirement of Dr. Lehman, Agricultural Chemist to the Mysore State, in 1910, he took charge of the latter's duties also. When the Mysore Agricultural Department was established in 1913, Dr. Coleman was appointed as its first Director, a post which he held till his retirement in 1934, save for a temporary period of absence during the War and various periods of leave.

As a scientific officer, Dr. Coleman will be remembered in India for his work on the 'Koleroga' disease of arecanut which resulted in control measures which are now in practical

operation, for his work on coffee diseases and for his work on the *jola* grasshopper. He was also a pioneer in the investigation of the 'Spike' disease of sandal, and he established its infectious character by grafting experiments and at a comparatively early date suggested that it was probably caused by a filter-passing virus. The Balehonnur Coffee Research Station, which is maintained jointly by the United Planters' Association of South India and the Mysore Department of Agriculture, was largely due to his enterprise and foresight.

To few agricultural officers is it given to build up an agricultural department from the foundations and to guide its activities for over twenty years. The success which Dr. Coleman achieved needs no emphasis and he has left behind him an active organization. In the Mysore State itself, he is perhaps best remembered by the attention he gave to the needs of the ryot, his close contact with him and intimate knowledge of his affairs. It was no unusual thing to find him in a peasant's cottage sharing with him his *ragi* gruel. He was looked on as a personal friend by cultivators throughout the State and his name will long be remembered in many a humble rural home.

Dr. Coleman started his Indian career at the same time as many of the senior members of the Indian Agricultural Service and was a regular and valued member of the Board of Agriculture in India. Not only was he personally popular, but he established a reputation for his department by the high standard of work on which he insisted. On the Board of Agriculture, the Indian Central Cotton Committee and latterly the Advisory Board of the Imperial Council of Agricultural Research, his scientific knowledge and sound judgment were recognized as an asset. Both plant-breeding and improvement of livestock came in for his active attention and he placed the plant-breeding work of the department on a sound footing and also reorganized the cattle and sheep-breeding. He was also responsible for the reorganization of the Sericultural and Veterinary Departments of the Mysore State and for the establishment of its Serum Institute. During the

last three years of his service, he was actively engaged in the establishment of the Mysore Sugar Factory at Mandya and with the general development of sugarcane production in the Irwin Canal area.

The recognition of Dr. Coleman's services to Indian Agriculture by the award of the C.I.E. in 1930 gave pleasure to a wide circle of friends and colleagues. Though he reached the normal retiring age in 1933, it had confidently been expected that he would serve the Mysore State and India for several years more. But this was not to be, for a serious illness followed by continued ill-health led to his retirement in 1934. His many friends in India trust that he will enjoy many years of happy retirement in the land of his birth and contribute still further to the advancement of agricultural science.

—*Agricultural and Live-stock in India,* Vol. V, Part IV.

Experiences regarding Cultivation and Curing of Virginia Tobacco

By

T. S. Raghavachar, B.A.

Land Owner, Kadgodi, Whitefield

My previous article on the cultivation of Virginia tobacco in Whitefield (*vide* Vol. XIII, No. 3 of this *Journal*) has elicited keen interest in the crop all over the State. Many have written to me asking for advice on various matters connected with the details of the cultivation and curing of the crop. Limited acreage under cultivation of this crop and want of capital to build barns have been great hindrances to the extension of cultivation of Virginia tobacco. As far as we, round about Whitefield, were concerned, the Indian Leaf Tobacco Development Company, Limited, had organized a branch at Whitefield, which not only educated the ryot in the art of growing Virginia tobacco but also taught him methods of curing leaf for cigarette manufacture. They also purchased small quantities grown by the ryot. This Company

have now practically closed their activities at Whitefield, not because the tobacco produced there was not good but they did not find it profitable to maintain a large establishment to buy only about a lakh of pounds of tobacco. The establishment is said to have cost them nearly as much as the cost of the leaf itself. It is learnt that the Company would be sending their agents annually during the season to purchase the cured tobacco. Though there is a great possibility of their doing so, it is not safe for us to entirely depend upon one company organization for purchase of the crop. I am afraid the cultivation of this type of tobacco will have to be given up if some efficient arrangement cannot be made to market the produce. But the recent developments indicate a hopeful future, for the Government have taken a hand in the organization of the cultivation and the curing of Virginia tobacco in this area. It is earnestly hoped that this move will give a great impetus to the development of the tobacco industry in this locality and help to extend it to other parts of the State.

The most important thing in the cultivation of tobacco is the minute attention that one should pay to the details. I, therefore, propose to deal in this article with some special operations in relation to cultivation and curing.

Seed-Bed

The best time for sowing the seed in the nursery seed-beds in this area is still a matter for experiment. However, in case the South-West Monsoon sets in early before the middle of June when the transplantation of the seedling in the fields has to be done, the seed-beds should have then been sown by about the end of April or the beginning of May. But the setting in of the monsoon fluctuates a good deal from year to year, in which case, the time of sowing should be regulated to suit the periods of transplantation which should be spread over a long number of days in order to avoid the possibility of crowding the transplanting time all over the area simultaneously and also the period of harvest for curing. It is undesirable and also impossible to transplant the whole

Sowing Tobacco seed.

Tobacco seed-bed ramping.

Shading Young Tobacco Seedlings with Date Leaves.

area at the same time. The best method is 4 or 5 sowings at intervals of a fortnight, or at least 10 days, to facilitate transplanting and later on curing in the barn in progressive and easy stages in order to avoid great loss.

Sandy soil is best suited for raising the seed-beds. If the soil is not sandy, plenty of sand should be carted and incorporated with the soil. The land meant for seed-bed should be well sterilized to get rid of insects and their grubs and eggs. In other countries where better methods of cultivation of tobacco prevail, the soil is said to be sterilized with steam but it is a costly process. We can, however, burn plenty of brush wood and obtain nearly the same results. The land should then be dug or ploughed and brought to a fine tilth. Plenty of well rotted cattle manure at the rate of 30 cart-loads to an acre should be mixed with the fine soil. In my experience, 10 cart-loads of cattle manure with artificial manures containing 18 lbs. of nitrogen, 30 lbs. of phosphoric acid and 60 lbs. of potash per acre have given excellent results. Drainage is very important in tobacco seed-beds, and there should be drains of one foot depth on both sides of the bed. The bed should be 4 ft. wide and may be of any length. It is advantageous to have cross-drains at intervals of about 20 ft. to facilitate movement of coolies to water the beds. There should be a number of water pits at convenient distances in the nursery. The earth removed in opening the drains is spread over the beds to raise their level slightly and to give a gentle slope all round to drain off extra moisture.

For sowing an acre of seed-bed, 4 lbs. of seed will be ample. If the germination of the seed is satisfactory, the seedlings would be sufficient to plant 100 acres of land. One table-spoonful of seed should be thoroughly mixed with four seers of clean dry sand. If there is strong wind blowing at the time of sowing, a screen should be held on the wind-ward side to enable the sower to sow evenly. Sand should then be spread over the seed-bed to a depth of one inch and the bed well trampled. Water should then be sprinkled by means of a water can provided with a rose. The bed should always

be kept moist. To help germination the bed should be covered, and for this purpose date leaves have been found to be satisfactory. The covering should be removed for a few hours in the day, especially if the weather happens to be moist. No covering is necessary after a week or ten days unless there is fear of wash-out from a heavy rain. Later, when the seedlings have begun to grow, if they are found too close they should be thinned, otherwise, they will have a very poor growth. Good seedling should be stout and hardy with a bushy healthy root system at the time of transplantation. Weeding in the beds should be done as often as necessary. When they are six weeks old, seedlings are ready for transplantation. At this stage, they will have put forth 4 to 6 leaves and will be about 6″ in height. It is usual to withhold water from the beds for about 4 days prior to removal to harden the seedlings for planting in the fields. At times, it may be necessary to hasten the growth of seedlings for early transplantation when nitrate of soda or sulphate of ammonia may be used at the rate of one table-spoonful in 2 gallons of water. Pure water should be sprinkled over the plants after the use of this liquid manure to save the leaves from scorching.

There are some common pests and diseases attacking the seedling and they should be properly combated. The one very common trouble in the early life of the seedlings is the Wet Rot which appears when the plant has just emerged from the ground and the seed-leaves are even with the ground. It spreads very rapidly and a whole seed-bed may be spoiled in the course of a few hours if immediate attention is not paid. In such cases, the practice is to remove at once not only the diseased portion with the soil to a depth of two to three inches, but also to treat similarly the surrounding healthy plants and soil to a distance of 6 inches all round. Quicklime is then put in the depression and water poured thereon. Small red ants carry away the seeds from the bed and it will be useful, therefore, if ant holes in the neighbourhood are treated and the ants destroyed. White ants often attack date leaves and thereby disturb the top soil and the small seedlings just emerg-

ing from the bed will be uprooted and damaged. To prevent this the date leaves should be removed, shaken and aired for some time, even if the removal of the covering might not otherwise be found necessary.

In the Whitefield area, borers attack the seedlings seriously and to minimise it the affected plants are removed and destroyed and the rest of the plants are sprayed with fish oil or Honge oil soap. Light traps can be used to catch the moths. The leaf-eating caterpillars also cause some damage and these are hand-picked and destroyed.

Raising the tobacco nursery is costly, troublesome and exacting, and the ryots, therefore, prefer to buy seedlings instead of growing them. To plant an acre in the field five thousand seedlings will be required and they cost about Rs. 7-8 and he may have to spend another Rs. 2-8 to fill up vacancies. Yet they prefer to purchase seedlings instead of raising them. Until now the purchaser of the green leaf for curing in the barn has been supplying seedlings on credit, the cost being recovered later on when payment is made for the leaf. If this practice is stopped, the ryot will grow his own seedlings and save a good bit of money.

Cultivation and Manuring

Heavy soils are not suitable for Virginia tobacco. Light soils, preferably sandy, should be chosen. It is stated that tobacco grows well in soils slightly acid. The preparation of the land is the same as for ragi and other dry crops. But it must be remembered that too much cattle manure will not result in quality-leaf. About 4 to 5 cart-loads of cattle manure would be sufficient and this is necessary to keep the physical condition of the soil in proper tilth. It would be still better if plenty of cattle manure is applied to a previous crop in the rotation. Groundnut one year, ragi next year, followed by tobacco is considered a good three-year rotation. It should be borne in mind that in the cigarette tobacco, too much nitrogen in the soil at the later stages of plant growth will make the leaf coarse and dark, qualities to be avoided.

Artificial manure have been found to be quite satisfactory in other countries for production of sufficient quantity with quality. As the results of certain experiments carried on here, it was found that against the ordinary average of 1,750 lbs. of green leaf per acre, production could be increased to 3,500 lbs. without sacrificing quality. The fertilizer-mixture in the experiment contained 21 lbs. of nitrogen, 36 lbs. of phosphoric acid and 77 lbs. of potash, and of nitrogen 11 lbs. was obtained from well-powdered groundnut-cake. It thus appears that if tobacco growing should be made a paying proposition, a decent quantity of artificial manure should be used with a small dose of cattle manure. If the full dose of artificial manure is used, the whole quantity may be incorporated in the soil by broadcasting. Otherwise, small quantities may be applied in rows.

Transplanting these is facilitated by running a cultivator with teeth 3 feet apart, both lengthwise and breadthwise. The junction of the lines will mark the position for every plant. Transplantation should be done in the evening and every plant should be watered with a watering can having a rose. Pouring water from a pot over the plant will injure the bud and the plant will die. If there be no rain, watering should be continued for 3 or 4 days by which time the plant will have established itself. Weeding and intercultivation should be done after the plants have attained a sufficient height and ridging has been found to give good results. The lowest leaves touching the ground should be removed to allow free play of air and prevent ash and spot diseases. When the flower buds appear, they should be removed along with a few inches of the stock with the leaves. Experience alone will show to what height the plants should thus be topped, the object of this operation being to divert the sap towards the leaves. Low topping will result in coarse and dark leaves and high topping in leaves of light colour, qualities appreciated in cigarette tobacco. Tobacco plant is said to require plenty of potash to produce high quality leaf and the object of topping is to divert potash to the service of the middle leaves instead

of going to seed formation for which potash is necessary. Potash deficiency is indicated by the small necrotic spots or specks at the tip and margins of the leaves which will be also chlorotic, also the leaves turn or tuck under at the tips and margins. "In extreme cases, the leaves become pukered and drawn and soon begin to dry up around the edges and between the veins." This spot disease appears during periods of heavy rainfall but in the field in which ridging has been done and the lower leaves of the plants have been removed, the disease will not appear. After topping, suckers will appear in plenty at the axils of the leaves and these should be removed as soon as they can be grasped with the fingers.

From about two and a half months after transplantation, leaves suitable for curing will be available in the field. Such leaves can be identified by their yellowish green colour. They will crack when folded and pressed between finger and thumb. Leaves of uniform ripeness should be picked and removed safely in carts to the barnside, without causing any injury. They will not cure properly in the barn if bruised, broken or wilted and, therefore, great precautions should be taken in picking and removing them. A field will have to be picked about four times at intervals of about a week or 10 days as the leaves ripen. After the last picking, the plants should be uprooted and removed from the fields or ploughed in if the damage done by borers and other insects and diseases is to be avoided in the subsequent seasons. If tobacco cultivation should progress in Mysore, a thorough control over the combating of pests and diseases is essential and a Pest Act should be passed for the purpose, if found necessary.

Regarding curing of tobacco two methods could be adopted in Mysore, namely, flue-curing and sun-curing. The first method is met with some success in the State and the details have been already described by me in my previous article. But not all the ryots can afford to build a standard barn at a cost of about Rs. 1,500, nor will each ryot be able to grow over 20 acres of tobacco to justify the construction of a barn to cure his own leaf. To some extent, specialization

in curing will pay very well. In this connection, it will be interesting to read the opinion quoted below of the *Journal of the Jamaica Agricultural Society,* Dec. 1933, on my suggestion in my previous article on the subject:—"The interesting suggestion put forward in the article is that the curing should be undertaken by a special class with small capital, who would buy the green leaf from the small farmers adjacent to his barn, and who would specialize on the technique of flue-curing and deal with the factories direct, certainly an idea worth considering." In any case, as the ryot has much to do during the season, in connection with his other crops, it will be useless to expect him to undertake tobacco curing also. Tobacco curing can be brought up to the level of that in countries like America and Rhodesia only if handled by persons with some means and education. I do not propose to explain in this article the method of flue-curing, as an excellent article on this subject appeared in the *Rhodesia Agricultural Journal,* Vol. XXX, No. 30, March 1933, by Mr. D. D. Brown, Chief Tobacco Expert, and it has been extracted for our use in Vol. XIV, No. 2, of this *Journal.* A perusal of the article will show that flue-curing of tobacco requires much knowledge and intelligence on the part of the curer and that greater these qualities are brought to bear on the work, the greater the profit. For this reason, it is better if educated people are encouraged to take up this work as a profession in these days of unemployment.

"In the curing process, moisture is gradually expelled from the tissue of the leaf, and certain chemical and physiological changes take place which bring about the desirable qualities in properly cured tobacco. During curing, the leaf is subjected to a gradual starvation, regulated by certain conditions. If by means of excessive heat or protoplasmic poisons, the cells are prematurely killed, the leaf will not be properly cured and will consequently lack in essential qualities."—D. D. Brown. Curing is at present done empirically by the ryots with whatever results that may be. There is no doubt that a knowledge of the fundamental factors will

lead to better work and there is much scope for investigation and research which might result in better mechanically-regulated control of the above-mentioned factors by a suitable alteration in the construction of the barn, or by mechanical contrivances which might be devised. Such knowledge of the factors and their control will, no doubt, lead also to an extension of the curing season. For instance, it has been found in Whitefield area that tobacco grows well until about December and January, but curing has been a very difficult matter. The leaf dies away quickly in the barn before the necessary physiological and chemical changes in the cell take place, and the colour of the leaf does not change to yellow. Such green tobacco is not at all marketable. There is so much scientific talent in our Agricultural Department that I fully hope that the matter will be tackled and remedies found.

Wood fuel, including such hard wood as casuarina, has not come up to the standard of fuel required for the curing barn. Coal is very nearly satisfactory, but it is imported from the outside of the State. Bengal coal, which has been found to be satisfactory, costs less than five rupees per ton at the source, but railway freight is about Rs. 20 per ton for Bangalore. The question arose why we should not use local electric power for the tobacco barn. It was, however, not found possible to find out without making actual experiments whether it would be cheaper or at least equal in cost. The Government of Mysore have taken up a proposition for experimenting at their cost and the results are awaited with interest. I have come across some reports of the Rural Electricity Commissioners, Victoria, Australia, from which it appears that experiments have been made by them for the benefit of their farmers, that the initial cost of the heating equipment was somewhat high and that the cost of curing with electricity at 1½*d.* per unit was not found advantageous as wood was cheaper. The Mysore Government charges ½ an anna per unit for heating purposes, namely, one-third of the Australian rate, and there is every hope of electricity being found cheaper than coal. It is worthwhile experiment-

ing. If coal is to be the deciding factor in the extension of cigarette tobacco cultivation in the State, I am afraid that the ryot will find it difficult to obtain it at places distant from the railway head and too costly to produce cured tobacco within a reasonable price and market the same. Electricity is being extended to various parts of the State and that alone should come to the aid of the farmer in this connection. There are greater advantages in an electric barn over the coal-fire barn, in that there is perfect control over temperature and sponging, the nightmare of the curer, has been completely eliminated. Further scientific experiments will be facilitated in such a regulated barn and can be successfully carried out with a view to raising the standard of curing and the extension of the season. The possibility of taking up sun-curing in places where flue-curing cannot be adopted seems to be a very doubtful one.

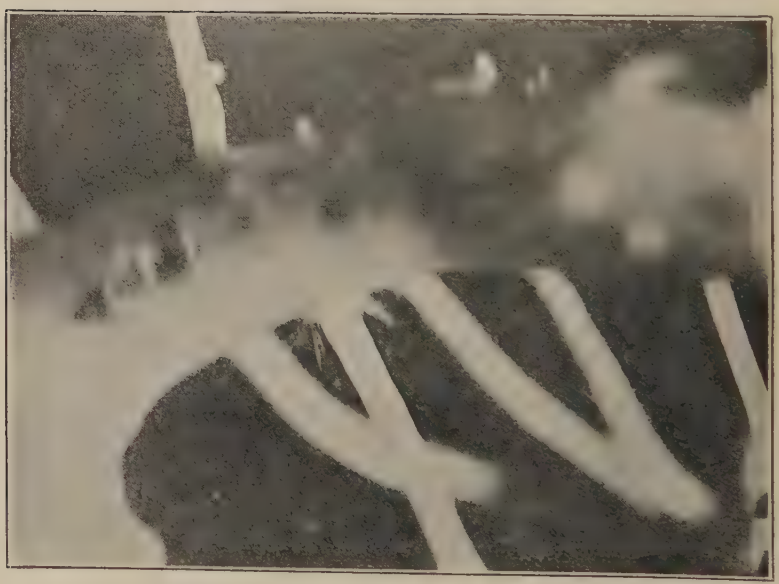
Sun-Curing.—In the years 1927 and 1928, tobacco was only sun-cured in the Whitefield area as barns had not then been introduced. As the result of the trouble and expense to which the ryot was put, he made up his mind to discontinue to grow tobacco. The Indian Leaf Tobacco Development Company, Ltd., built barns in the year 1929 and agreed to buy green tobacco from the ryot, and since then the cultivation has been going on. The ryot or any other person or any company is not likely to do sun-curing of tobacco for the following reasons. Such curing takes about a month and sometimes more to complete owing to the uncertainties of the weather. Racks have to be erected in the open and whenever there is a likelihood of showers of rain, the tobacco has to be carried indoors where also it has to be kept well aired until taken out again. In this area, during the monsoon, the leaf kept for curing turned black under the best managed conditions. Sun-curing was possible during those years when there was failure of North-East monsoon. As it is difficult to forecast weather conditions in this area, sun-curing is, however, a risky affair.

I understand that sun-curing is still being practised to some extent in the Guntur District in the case of country

Spraying seed-beds with bordeaux mixture on the left.
On the right, seed-beds with seedlings ready for planting.

Watering Tobacco seedlings.

Root hairs on the lateral roots of groundnut plant.
They are usually produced in moist, well-aerated soils.



Rosette of hairs at the base of the lateral roots.

tobacco and the inferior Virginian leaf. Weather conditions prevailing in that district appear to be very different and as the curing takes place after the cessation of the rains, sun-curing is not a difficult matter there.

Botany of Groundnut*

By

V. K. Badami, L.Ag., Ph.D. (Cantab.)

II

Root Hairs

Pettit[7] and Richter[8] did not see any root hairs. But Waldron[9] by careful manipulations was able to show poorly developed root hairs near the tips of young lateral roots and none on the main roots. He also showed that at the base of the lateral roots there were rosettes and they were stimulated to form by high humidity and temperature. He found them on the young plants whose roots grew in moist air and old plants which were renewing their growth. Saturated heavy soils retarded the growth of rosette hairs, and inhibited root tip hairs. Reed[1] observed only a few rosettes on the field-grown plants. The general method of absorption is by the mucilaginous epidermis of the roots. The roots stick to the soil and absorb moisture.

In Cambridge I found the formation of root hairs of rosette type quite common both in the pot-grown plants and in the field-grown plants. They are very small and delicate and it is difficult to free them from the clinging soil particles. If washed with water they get damaged and collapse. That is why they are not easily seen. When the lateral roots are

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* The first part of this article appeared in this *Journal*, Vol. XIV, No. 4, February 1935.

7 Pettit, "*Arachis hypogeæ*", *Mem. Torr. Bot. Club, IV*, 1895.

8 Richter, "Beitrage zur biologie der *Arachis hypogeæ*," *Inaug. Diss.*, 1899.

9 Waldron, R. A., "The Peanut (*Arachis hypogeæ*)—Its History, Physiology and Utility," *Contr. Bot. Lab. Univ.*, part V, 4, No. 2, 1919.

formed in moist air or in the soil they develop freely. I am inclined to believe that the formation of root tip hairs also is not uncommon. I fail to see how the plant can be so erratic as to produce them at some times and not at others. At any rate, these two types of hairs do exist in the plant and help the plant to absorb soil moisture. The root tip hairs do not seem to be so near the root tips as in other plants. The observations made at Cambridge show that they develop an inch or an inch and a half behind the tips and are fairly numerous. They are short and delicate being about 1 mm. in length. In 1927 and 1928, I tried to grow a large number of seeds in the seed germination box where the sand is always moist and the enclosed air saturated with moisture. The rosette of hairs at the base of the lateral roots were always produced at a room temperature of 22°C. Only in one or two cases root hairs were found on the lateral roots about an inch from the tip. But when the temperature was over 31°C., almost every lateral root produced masses of root hairs (see photographs). To me it seems that the production of root hairs depends upon the temperature and moisture in the soil, and that the root hair production is quite common under field conditions. In the absence of root hairs the highly mucilaginous epidermal layer of the roots clings to the soil particles and absorbs moisture. Thus there are three agencies for the roots to absorb water: (*a*) mucilage, (*b*) rosette of root hairs at the bases of lateral roots, and (*c*) usual root hairs on rootlets.

If groundnut seeds are soaked well in water, placed over moist sand or saw dust and placed in an incubator at a temperature of 25° or 27°C. the seeds begin to germinate from 12 hours to 3 days. When the radicle has elongated and the root begins to develop if the tip is clipped off, the lateral roots soon form in numbers. At this stage large numbers of them possess root hairs of the rosette type. It is possible to obtain good examples of root tip hairs as mentioned above. It is advisable to cover the tray in a box containing the seeds with a glass to prevent the seeds from getting dry in the incubator.

The plant seems to utilize these root hairs to a large extent for getting its supply of soil moisture.

The roots are similar to those of other dicotyledons. The pith cells are full of starch grains. There are many medullary rays. Many cells in the cortex and the piths are filled with tannin. There is a central hollow in older stems.

Leaf

The leaf is compound with four leaflets in two pairs. Petiole varies from 1 cm. to 3 cm. in length. Lower third is attached to the stipules which enclose and protect the leaf in the bud stage. In the bud leaflets are folded inwards individually and the lower ones are on either side of the upper pair. They seem to be all on a level. As the bud expands the leaflets spread and the petiole lengthens out carrying the upper pair a little further, about 1 cm. Then the expansion takes place. When the petiole is tender it is clothed with hairs. The margin of the leaflet is fringed with hairs. Few stray hairs are found on the under-side of the leaf, and many more on the mid-rib and veins, especially near the base on the lower surface. Along the edge of the leaflet runs a vein and this system of vascular bundles prevents the leaf from curling and keeps it always flat. The leaflet is thick and leathery. Upper surface is dark green in spreading varieties and light green in erect ones. The lower surface is whitish on account of a layer of big water cells. There are many stomata both on the upper and lower surfaces of the leaflet. Varieties with dark green leaves seem to be more disease-resisting than those with pale green leaves, and also they seem to be more hardy and drought-resisting.

The leaf has nyctitropic movement. The petiole bends downwards at the pulvinus. The upper pair of leaflets fold and bend upwards and the lower pair fold up and enclose the upper pair. This closing takes place only loosely. The same thing happens when the sun is severe or during sweeping hot winds.

Reed[1] observes that "*Arachis* has strong xerophytic tendencies, which make the leaf structure quite striking. Stomata

are present on both sides of the leaf in large numbers. They are even with surface, as in plants having mesophytic characters, and are of average size. The leaflet shows a well-developed cuticle, a single layer of epidermal cells, a palisade consisting of two to four layers of cells with numerous air spaces, a narrow, loosely arranged sponge tissue, a single layer of water storage cells and a single layer of epidermal cells with a cuticle which is not so well developed as that on the upper surface. Quite regularly certain cells of the upper epidermis project inward, forming an inverted cone which extends about 1/3 the diameter of the leaf. These are tannin cells which appear dark brown in stained slides." On the basis of his study of leaf structure, Reed concludes that *Arachis* is mesophytic in character but finds it difficult to explain the strong xerophytic tendency of the plant.

In the first instance, stomata are not simple in structure.[1] They have ring-like structures both on the surface and inside of the leaf. A cross-section of leaf cut through a number of stomata shows their true appearance. It is seen that the structure is complicated and well fitted for controlling transpiration. Rings on either side act as sphincters and the guard cells control them in opening or closing. The structure in cross-section looks like a pair of hooks facing one another. In thin sections of only 10 mm. bright light will not reveal these translucent structures under the microscope. Thicker sections are not quite good to make a study of them. By regulating the light and examining a number of sections the modified structure may be easily seen. Secondly, the row of water cells on the lower surface is very efficient. These cells are very big and store much water. They occupy much of the space that would have been occupied by spongy parenchyma and therefore only a narrow strip of spongy parenchyma is present. In the young leaves these characters are not fully developed. Hot house plants also do not present the structure of normal plants. Fully developed healthy leaves are essential to note the normal structure. Thirdly, on the upper surface big water cells are found scattered all over the leaf.

They are raised slightly like a dome above the general surface of the leaf. Fourthly, a point that has not been so far observed is the row of water cells connecting the upper and lower surfaces of the leaf. They are devoid of protoplasm or chlorophyll and they connect the lower layer of water cells with the upper layer of water cells below the epidermis, or the vascular bundles with the lower and upper layers. These rows of connecting water cells give the appearance of galleries and divide the palisade cells into different compact blocks. Generally, each row consists of one vertical layer of cells. But in places where they conduct water out of bigger vascular bundles, sometimes two rows are observed. From the vascular bundles in the mid rib two or three rows connect them with the cells of the upper epidermal cells. These structures clearly indicate that in this plant the leaf is well constructed to behave as a xerophyte during dry spells.

Reed's Observation

Reed[2] states that the plants found in the vicinity of his experimental plots were both xerophytic and mesophytic in character. The sandy soil was 8 to 12 inches or about 20 to 30 cm. deep and lay over a clay subsoil. The drainage by percolation through the clay was therefore very poor. His examination of water content in different layers extended only to 15 cm. depth.

The seeds were sown 3 to 5 cms. deep, and the assumption was that *Arachis* developed a tap root less than 4 or 5 inches. He says that *Arachis* has a "well-developed tap root". A tap root only four or five inches long does not seem to be a well-developed one among cultivated crops.

It seems to me that the ill-drained clayey subsoil was stored well with moisture during the previous heavy rains and that the tap root was utilizing the subterranean store of water all the time. My observations show that the tap root goes down much further than 15 cms. I had instances where the fine stringy terminals were traced down to about 50 to 55 cms. The development of a vigorous tap root and the structure of the leaf tend to show that *Arachis* plant is well fitted

for tiding over droughts, if not typically xerophytic in character. Waldron did not rely on the nature of the stomata but on the other characters and believed the plant to be a xerophyte. There are many tannin sacs but very few like the one described by Reed. Generally they are on a level with the palisade and lie just below the epidermal layer of cells. There are many cells in the upper surface of the leaf with solitary crystals of calcium oxalate. The hairs on the leaf as in other parts are filiform and multicellular trichomes. There are two or three small cells at the base and the cell at the tip is elongated ending in a tapering point.

Flower.

The long calyx tube and the development of the pod below ground confused botanists for a long time before 1805. Poiteau correctly described the structure of the flower in that year and Brown confirmed it in 1816. But in 1839 Bentham wrote that *Arachis* had dimorphic flowers. He looked upon the one with calyx and corolla as sterile. His description of the fertile flower was that "from two bracteoles, similar to those which are formed at the base of the sterile flowers proceeds a stiff, rigid, style or torus which is speedily reflexed and elongated, and is terminated by, what appears to the naked eye, a short point. Examined under a lens, this point discloses at its extremity a truncated somewhat concave and dilated stigma." When in 1865 Veissler described all the flowers as petal-bearing and fertile, Bentham remained unconvinced and published a reply in the same year. Bentham mistook the scar of the style as a stigma and the elongated "peg" or gynophore as a claistogamous flower.

All flowers are complete and are produced above ground. It is only when the branches are buried under ground flowers are found within the soil, sometimes several inches below the surface. In such cases there is no chlorophyll in the calyx but the petals are coloured yellow.

Flowers are borne in leaf axils. Generally they are three in an axil but four are not uncommon. Each bud opens in

succession one after the other at intervals of 4 to 5 days. The buds in the leaf axils nearer the main stem blossom simultaneously and they have very short calyx tubes. There are at times gaps in the leaf axils. Instead of producing flowering buds only leaf buds are formed. The lowest two or three buds are mostly vegetative. As the lateral branch grows fresh buds are formed in the new leaf axils sometimes up to the last leaf axil. A number of weeks elapses between the flowering of the buds at the base and the tip of the branch. This factor coupled with succession of flowers at each leaf-axil extends the duration of the crop. If all the flowers develop at the same time as they do near the base of the branches at least a gain of nearly two weeks may be made in shortening the ripening period of the crop.

On the central stem, generally, vegetative buds are formed. In the erect plants in each leaf axil there is generally a short fruiting spur. There are two or three flower buds and a vegetative bud in a leaf axil. When the vegetative bud develops it has in its turn three fruit buds and one vegetative bud. Thus the short fruiting branches are responsible for the grouping of many nuts round the base.

The calyx is synsepalous having a tube about 1½ inches long crowned by fine irregular calyx tips. For a long time this tube was mistaken for a peduncle.

The Corolla is typically papilionaceous, consisting of a standard, two wings and a keel. All these are inserted at the top of the calyx tube. The Corolla is orange yellow in colour. Venation in the standard is scarlet in colour to half the length.

Stamens are 10, 8 or sometimes 9; monodelphous and the filaments are fused to about two-thirds of their length. When one or two stamens are sterile they are almost fused with the filaments of the fertile stamens.

There are two sets of anthers. Four are longer, bigger and basifixed and contain four locules. They develop first. Four others are on shorter filaments. They are formed and developed later than the first set. They are two-loculed and

versatile. After the first set of anthers have liberated their pollen, the filaments of the second set still elongate and grow longer than the first set placing the anthers above those of the first set. Sometimes the anthers are deformed and often the pollen development is defective and many abortive pollen grains are formed. The pollen grains germinate easily in a moist cell.

The pistil is sessile. A single carpel is formed by the union of five capillary leaves, as shown by Miss Saunders. The style is curved upwards and ends with a hook-like stigma. On the inside of the style near the stigma there are hairs which are slanting and facing upwards.

The stigma and the pollen reach maturity at the same time. The covering calyx begins to split in the evening and the standard of the corolla slowly unfolds during the night. By about midnight the petals are free and begin to spread out. By early morning the flower is fully developed. At sunrise the anther sacs burst and self-pollination takes place. In about 2 or 3 hours a large number of pollen grains germinate. By noon or in about 5 hours the pollen tubes pass down the style beyond the top of the calyx tube. Fertilization takes place in about 30 hours. As soon as the egg is fertilized the base of the ovary, *i.e.*, the internode between the ovary and the receptacle, begins to elongate. Actual growth of the ovary takes place in two or three days, but the lengthening of the stalk behind the ovary is noticeable on the fourth or fifth day. The elongation is rapid. After growing two or three mms., the tip bends down towards the earth. Though the stalk or "peg" or gynophore is stem-like in structure, it is geotropic in character. The gynophore penetrates the soil to 2 inches or 3 inches and develops into a fruit which, on ripening, becomes the nut.

Elongation is caused by the meristematic tissue behind the ovary. As soon as the development of the ovary begins, it takes a horizontal position and the ovules come to lie parallel to the surface. Swelling of the ovary takes place quickly.

It contains a spongy mass and is filled with a sugary sap. Then the ovules begin to develop. The walls of the ovule or integuments grow thick and swell up in size. Inside, the nucellus is hollow and filled with sap full of starch grains. Till the carpel has swollen out and the ovule has begun to develop, the embryo is more or less dormant. Then it begins to develop slowly. The fleshy cotyledons are quite leaf-like in character in the early stages. Then, they swell and become fleshy. Finally, the two cotyledons fill up the whole cavity of the nucellus. There is no endosperm in the fertilized ovule. It is represented by a single layer of cells around the embryo and as the embryo develops, it becomes a mere lining to the integuments. The embryo gradually occupies greater space by feeding on the stored nutrient materials. As the embryo develops, the integuments also develop along with it. Finally, the integuments are reduced to a thin layer. The pericarp becomes hard and leathery, forming a shell. The meso and endocarp turn out pithy and form the soft part of the shell. The integuments also get thinner and remain as seed coat. The layer of endosperm cells, being indistinguishable, the whole seed consists of a highly developed embryo, with a covering of a thin layer of integuments.

There may be two, three or even six ovaries in some varieties. They are all epitropous, and embryos are straight. The lowest embryo develops first and then the next in order. If there is a failure in development, it is the topmost ones that generally fail first, and they are seen as immature, shrivelled seeds.

Darwin[10] showed that the growth of the gynophore downwards is due to positive geotropism. Waldron found some granules in the lumen of the tip cells, and suggested the geotropic movement to the stimulus given by them. In a series of tests made by me, I found that clipping off of the tip did in no way affect the geotropic effect. A few gynophores were turned upside and tips clipped. In a few days they all turned downwards. On the other hand, if the developing embryos

[10] Darwin, Charles, *The Movements of Plants.*

are killed or destroyed by pin pricks, or even removed without injuring the tips, it was found that the growth stopped immediately and there was no stimulus for the tips to turn down towards the ground. In one of the graftings made by growing a healthy young gynophore with the developing embryos on the stump of an old gynophore, it was found that the growth was renewed for some time. The tip turned towards the earth but no union between the scion and stock took place and the grafting failed. Any number of pin pricks or even cutting half through the gynophore without injuring the embryo had no effect on the geotropic growth. I am, therefore, led to believe that the seat of stimulus is in the developing embryo and not, as Waldron suggested, in the lumen of the tip cells which contain granules.

The tip of the gynophore is glabrous, pointed and tinged violet. Just below the ovary dense hairs are formed and they fall off as the gynophore elongates. When the gynophore enters the soil it loses chlorophyll and assumes a dull white colour. In moist light soils, specially in sands, masses of hairs like root hairs are formed. They cling to the soil particles. They may absorb moisture to swell the developing pods. It is not likely that they act as root hairs to absorb soil moisture for the whole plant.

A series of experiments were made to find out the reason for the development of pods at certain levels in the soil. That they want a certain amount of moisture and warmth is known but what exactly starts the development is not known. The results of the experiments are as follows:—

1. In moist air the gynophores grew as long as the vitality in the plant lasted but there was no development of pods. Just behind the tips white hairy structures were formed. Some of the gynophores developed up to ten and twelve inches. In moist air almost every flower sets in a plant and induces the elongation of the gynophore. When there are rainy periods it is seen in erect plants that a large percentage of flowers in the upper portions of the branches sets and produces gynophores in numbers. Many of them are so far

from the ground that they fail to reach the ground and set seeds. If they are buried underground they set seeds.

2. Gynophores let into tubes of dry sand, lingered for some time and then withered.

3. In wet sand they grew downwards very vigorously and formed plenty of hair structures. The depth to which they grew was more than twice the usual depth.

4. In tubes filled with garden soil and two inches of sand as top layer, gynophores began to develop pods as soon as they approached the layer of clay soil.

5. In the tubes filled with clay soil the formation of pods started within an inch or two of the surface.

In addition to moisture and warmth, a regulation in the supply of air and light also seems to have an influence over the development of the pod.

Properly developed nuts, when they are quite ripe, germinate immediately after a rain if left in the ground. But when the nuts are harvested and heaped in threshing floors, a sweating takes place. If proper precautions are not taken, they get mouldy. Generally it is believed that fresh nuts are not good for sowing and a year old seeds are considered to be good. Experiments bear out this belief. In many cases I had not more than 10 or 15 per cent. germination when fresh air-dried pods were used for seed. After the pods are fully air-dried in shade and then in the sun, a good well-dried sample of seeds can be shelled. If these seeds are dried in the hot sun for a week from 8 to 10 hours a day, an admirable sample of seeds giving 96 per cent. germination can be obtained. A good germination is very necessary to prevent blanks in the field and to reap bigger harvests.

Cytological investigations made by me have shown two groups of groundnuts. Spreading type of Virginia contains 20 chromosomes haploid and the erect type of small Japan contains 10 chromosomes haploid. The chromosomes of the small Japan were found to be bigger in size than those of the Virginia.

A large number of spreading and erect varieties are now under observation in the breeding plots. Attempts are now being made to classify them on the basis of number of chromosomes they possess. *A. nambyquarensis* has been growing quite well and many successful crosses have been already made between this new plant and different varieties of groundnut. If a collection of all the allied species of *Arachis* is made in Brazil and made available to the plant breeders in other countries, a new epoch will begin in the improvement of this important commercial plant.

Sheep Breeding in Mysore

By

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Climate and Sheep.—In point of climate, Mysore falls into two main divisions, the region of heavy rainfall known as the malnad, which is mountainous and hilly with a rainfall of about 70 to 300 inches, and maidan which is a less rugged country with a rainfall not exceeding 20 to 35 inches on the average. On account of climatic and ecological factors, and geographical conditions, sheep do not thrive in the malnad parts and are not reared there, but in all maidan parts sheep rearing is an important industry and is done on very haphazard lines, as they are chiefly prized for their manure.

Sheep Census.—According to the last quinquennial census, the total number of sheep in the State is 28,21,134. According to Districts, the number is as follows:—

1.	Tumkur	6,90,121
2.	Mysore	6,45,479
3.	Kolar	5,25,001
4.	Chitaldrug	3,21,735
5.	Hassan	2,76,223
6.	Bangalore	2,61,391
7.	Kadur	72,148
8.	Shimoga	29,036

Geographical Position, Climate, Rainfall and Temperature.—The situation of these districts is between 12° 15′ and 15° 2′ North Latitude and 75° 42′ and 38° 3′ East Longitude and their general elevation varies between 2,000 feet to 3,000 feet above the level of the sea. The areas, temperature and rainfall are as shown hereunder :—

District	Area in square miles	District average rainfall	Mean temperature
Tumkur ..	4,054	26 inches	83°
Mysore ..	5,463	28 „	77°
Kolar ..	3,187	28 „	80°
Chitaldrug ..	4,179	21 „	77°
Hassan ..	2,666	38 „	72°
Bangalore ..	3,076	30 „	76°
Kadur ..	2,775	73 „	72°
Shimoga ..	4,179	56 „	78°

Soil.—The prevailing soil is red loam in the southern and western parts of Tumkur District, sandy in eastern taluks and black in the northern. Mysore abounds in red soil. The soil in high grounds of Kolar is red and gravelly, the top of the ridges being practically barren. The soil of Bangalore is again red loam in every variety of colour, from light to dark red. The black cotton soil prevails mostly in the Chitaldrug District, red and loamy soils occupying the valleys. The black soil occurs in patches in the maidan part of the Hassan District.

Distribution of Rain and Pastures.—The rainfall in the eastern portion of the State is heavy during the North-East Monsoon. In the middle and western portions of the State, a large portion of the rain is received during the Pre-Monsoon and South-West Monsoon period on the strip of country lying along the margin of the malnad. Though the average rainfall is similar to that of the plains, the distribution is over a greater number of days and therefore pasture is in fairly good condition for a longer period in those parts.

Grasses and other Feed.—Several species of Andropogon, Ergrostus, Paspalums and Panicums are found on average

pastures during the rains. On more moist grounds species of Elucina, Cynadon, Pannicus and several kinds of sedges are usually found. These are mostly very different from those found in other parts of sheep rearing countries. In addition to these, there are several legumes and edible shrubs which require to be carefully surveyed. During summer nights, foliage of Ficus varieties like Basri, Ala, Jali foliage and pods are also fed.

Grazing and Development.—In developing animal husbandry grading up is done by importing sires from foreign countries. The natural herbage which is able to support in health, slower growing native sheep that have evolved on this herbage, is too poor in constructive material to support more rapidly growing animals. The equilibrium between the grazing and the herbage is upset and the resulting mortality is really a natural process tending to the elimination of a type whose rate of growth inherited from the sire is greater than the herbage can support. The flocks of sheep owners possessing cross-bred progeny do not receive any special attention. It is the general law in nutrition that the faster the rate of growth of the animal, the richer must be the food in constructive material required for bone and tissue formation and any method of supplying the deficiencies could only be second best. To add to this, the poor pasture throughout the sheep-rearing tract is highly infested with parasites.

Sheep Generally a Source of Manure.—Sheep are owned generally by the poorest class of villagers and are looked upon as "walking dung carts". If a rich landlord owns them he owns them for the sake of manure and not for the sake of wool and the entire management is in the hands of his tenant or menial who is not interested either in castrating undesirable rams or in selection in the flock for improvement of wool or mutton.

Breeding Season, Care of Ewes and Rams Neglected.—The breeding season in the State begins usually after the showers in April. The whole male stock of the village, whether of breeding age or not, move about throughout the

General view of improved village flock, Sabbanahally.

Half bred sire, Mysore dam and their progeny.

Half bred ewe (Merino *vs.* Mysore).

year with the female stock. The facts that a breeding ewe has to maintain her body, grow her wool, provide for the growth and development of the unborn lamb and provide milk for its sustenance after birth, do not worry the sheep rearer in this country. Even a well-to-do landlord has not for his object the rearing of sheep for the production of a commercial commodity and to produce it in such a manner and of such quality and in such quantity that it will allow a reasonable profit over the expenses incurred in producing it.

Grazing in Arable Lands.—At present sheep usually derive their grazing from the stubble left after the crops are reaped and the grass grown thereafter. It is an advantage to have the sheep graze on the field and get the manure but so long as the bulk of the flocks are maintained in this way there is no prospect of any great improvement in the types kept as the shepherds, under such circumstances, attach more importance to numbers and quick breeding than to quality. It will be necessary to give special facilities to persons who wish to take up sheep rearing on a large scale by giving them land for grazing, etc., on concessional terms.

Shearing.—Clipping is done twice a year almost invariably in Mysore with an implement, something like a large pair of scissors. A considerable amount of wool is lett on the sheep, there are many second cuts, that is, the wool is not cut close enough and a further portion is removed with another cut of the shears. This results in a lot of short staples being in the fleece which reduces its value and there is no system of sorting of wool. From the standpoint of wool production, the local sheep are very deficient, probably averaging a clip of eight ozs. *per capita*. This method of clipping which results in further reducing the length of the staple makes it difficult to spin into a fine, strong yarn and the fleece contains dust and short fibres which are lost in the process of carding and cannot be utilized. Even with this clipping and ordinary washing the fleeces harbour vermin and the washing with water, besides removing the yolk of the wool,

renders the fleece harsh and open, and reduces protection against rain, twigs, etc.

Sheep of Mysore and Neighbouring Presidencies.—As far as sheep in Southern India are concerned, *i.e.*, Mysore and the adjacent parts of Bombay and Madras Presidencies, there is not much difference either in the varieties of sheep reared, method of rearing and clipping wool, etc., and if anything, Mysore sheep, on account of better grazing and climatic conditions, and demand for better varieties of mutton, are, on the whole, of a better type. Even in Mysore, it is possible to find types which are better suited for development of mutton and those in which the fleece would be more valuable.

The Mysore sheep can be grouped under two types, one in which the conformation suggests symmetry, compactness, large size and mutton quality with scarcely the vestige of a fleece, as there is hardly 5 per cent. of wool on its body, and in which the adult weight in ordinary condition is about 65 lbs. and the other a small bodied and light one that seldom attains a greater adult weight than 50 lbs. but carries a good fleece.

Yield of Wool: Country and Improved.—The following is a comparative statement of clips obtained on the farms:—

Breeds	*Highest.*		*Lowest.*		*Average.*	
	Lbs.	Ozs.	Lbs.	Ozs.	Lbs.	Ozs.
Merino ewes ..	10	0	8	0	9	0
Merino rams ..	13	0	10	0	11	8
Half-bred rams ..	3	12	1	8	2	3
Half-bred ewes ..	2	12	1	1	1	7
Quarter-bred rams ..	3	0	1	8	2	4
Quarter-bred ewes ..	2	4	0	12	1	8
Double half-bred rams ..	3	4	2	0	2	8
Double half-bred ewes ..	2	8	1	4	2	0
Three-fourth bred rams ..	3	12	1	4	2	0
Three-fourth bred ewes ..	2	12	1	1	1	8
Five-eighth bred rams ..	3	0	1	8	2	4
Country rams ..	1	12	0	8	0	12
Country ewes ..	1	0	0	6	0	8

When an exchange is effected between the shepherd and the weaver, the usual rate is one *kambli* worth about Rs. 3 to 4

Quarter bred ram. dense wool full of crimp.

A group of cross bred lambs in Sabbanahally Village Flock.

A group of cross bred ewes in Sabbanahally Village Flock.

Shoulder wool of No. 4 showing fineness and crimp.

for wool of 50 sheep, or about 1½ anna *per capita*. No dipping is done. Fine quality of wool finds little favour as the hand weaver is unable to spin fine wool into good yarn, and small output of fine wool finds no sale in local mills. In either case, the return is not very high. Hence, it is important to put *kambli* weaving industry on a fairly good basis.

Sheep Breeders' Association, Kolar: Extension Work.— With a view to educate the raiyats in improved methods of sheep husbandry, the Kolar District, which is one of the biggest sheep breeding areas in the State, was selected in 1923 for some propaganda work. Such work among the sheep breeders themselves was in the form of introducing machine clipping, encouraging annual in place of semi-annual clipping, dipping every six months, and the formation of pure white flocks instead of the motley flocks usually maintained, and the distribution of cross-bred rams. All of these lines have been well received, and it has only been the lack of staff and other facilities which have prevented its spread to a generous extent. As a development of these activities, a number of interested sheep breeders of this district were organised into a Sheep Breeders' Association, which has as its object, the following:—

(1) Expansion of sheep husbandry and the introduction and popularization of superior breeds of sheep.

(2) The gradual replacement of black sheep by white ones in the raiyat's flocks with the ultimate object of maintaining pure white flocks.

(3) Providing an adequate supply of white country sheep and superior breeds of sheep for the foundation flocks of members.

(4) Establishing pure-bred flocks of superior breeds of sheep.

(5) Improving the quality and quantity of wool and mutton.

(6) Providing and creating facilities for shearing, dipping and veterinary aid.

(7) Creating market facilities for wool and stock.

(8) To assist the Agricultural Department to conduct experiments pertaining to the improvement of sheep husbandry.

(9) To move the Government for executive or legislative action conducive to the prosperity of the industry.

(10) Arranging for lectures, short courses, educative demonstrations, exhibitions and sheep shows.

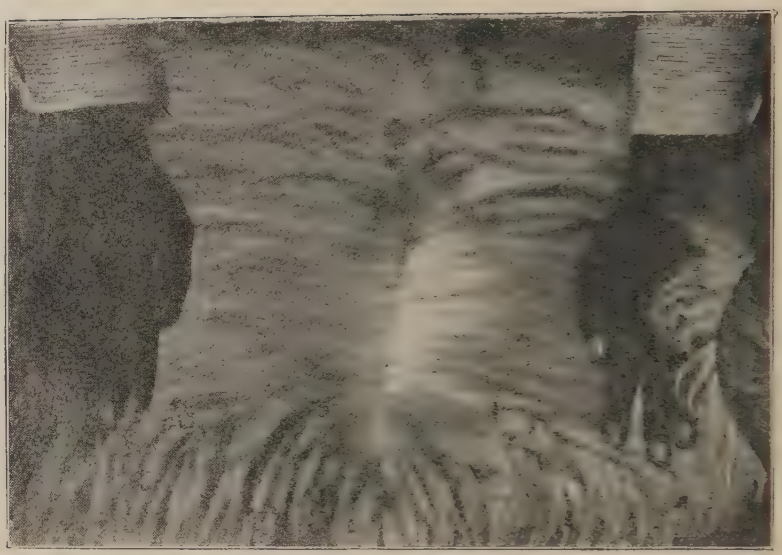
(11) To do all other lawful acts as are incidental and conducive to the attainment of any or all of the above objects and for the particular improvement of the industry.

All the white sheep of members who are using cross-bred rams, are registered in an Association flock-book with a view to further registration of all acceptable progeny, a development which may prove of considerable value later. The departmental assistance to this Association consists of a fieldman who does most of the clipping and supervises dipping operations, etc., and an Agricultural Inspector who acts as Secretary of the Association, oversees the work of the fieldman, and renders as much assistance as he can.

The number of members on the roll has risen from 104 in 1923–24 to 205 at the end of 1933–34. The main work in the earlier stages consisted in educating the members who were mostly owners of very small flocks to replace their black and coloured sheep with white ones. As most of these members could not afford to pay the cost of white sheep, the department arranged to sell their coloured ewes and supply them with white ewes. All the undesirable rams in their flocks were castrated, and white local rams were supplied. As the demand for white ewes increased, a small breeding flock was started at Kolar in 1929, and the progeny is being sold every year to the members. Cross-bred rams produced on the Government Farms are supplied every year to the members, and whenever surplus stock of cross-bred ewes are available, they are also sold to them. Whenever Merino rams could be spared, they have been allowed to render service in the members' flocks during the breeding season. The total number of cross-bred stock supplied from Government Farms

General view of the Farm Flock.

Breeding Ram, Mysore, horned.



Shoulder wool of No. 2.

Breeding Ram (2) and his male progeny.

to the members during the past 10 years is a little over 300. Progress in this direction is very little and slow on account of various reasons, *e.g.*, want of funds, and facilities to maintain an extensive farm to produce a large number of cross-breds, severe culling among the stock produced, mortality, etc. The total number of sheep under the control of the Association now amounts to nearly 10,000. The number would have been almost double but for the widespread prevalence of parasitosis three years ago, when the members were obliged to sell most of their stock for mutton, to prevent serious loss.

Remarkable improvement has been achieved by some of the members of the Kolar Sheep Breeders' Association who have taken keen interest in sheep improvement. By introducing cross-bred rams in their pure white flocks of local ewes, and by culling out progeny with wool that was coarse, characterless, admixed with hair, and variable in colour, and by practising rigorous selection, they possess very good flocks. The best of such flocks is owned by a member in Sabbanhally. The wool of most of his sheep is free from kemp, dense and fine with a close regular crimp. The wool yield of the flock is 2½ times that of a similar flock of local sheep.

Machine shearing has gained wide popularity, but the staff for the work being limited, not more than 9,000 sheep could be machine shorn during the clipping season. A portable dipping tank is carried from village to village and the flocks of the members are dipped regularly twice a year. Some of the villages have built their own dipping tanks. The cost of the dip and the expenses incurred in connection with dipping and clipping are borne by the department.

The wool clipped through the agency of the Association along with wool clipped and sent over to the Association by the members is graded and sorted and sold on a co-operative basis to the local mills in Bangalore and to the Government Jails at Bangalore, Mysore and Vellore. This activity was started in 1925, and so far, the Association has sold 62,000 pounds of wool of all grades, realising thereby a gross value of Rs. 14,000. The maximum and minimum price obtained

for wool of different grades is as given below :—

Kind of wool	Country White wool		Mixed wool		Cross-bred wool	
	Max.	Min.	Max.	Min.	Max.	Min.
Year	1929–30	1931–32	1928–29	1932–33	1928–29	1931–32
Rate per pound	Rs. A. P. 0 8 10	Rs. A. P. 0 3 10	Rs. A. P. 0 5 0	Rs. A. P. 0 1 5	Rs. A. P. 1 2 0	Rs. A. P. 0 2 10

The flocks of the Association are regularly dosed with anthelmentic mixture as a precautionary measure against stomach worms, and the Civil Veterinary Department renders necessary assistance during outbreaks of infectious and contagious diseases.

Since 1929, when the price of wool fell down, the Association, instead of selling all their cross-bred wool, have been using small quantities of the same in manufacturing a few woollen fabrics, such as carpets, coating and blankets by setting up pit and shuttle looms. These articles are highly appreciated on account of their fineness and durability and fetch good prices.

Local Wool.—Black, brown, and white colours are found, both pure and in mixture, while the wool is of a coarse kind consisting of wool, kemp and heterotypic fibres in the small bodied type, the length of the staple in certain rams being as long as that of black faced sheep, 5 to 6 inches.

Weight of Cross-Breeds.—The birth weights of crosses have averaged from 5 to 6 lbs. as against half that weight of local lambs. They attain a weight of about 30 lbs. at six months while a native sheep takes three times the period to attain the same weight.

Wool of Cross-Breeds.—A quantitative analysis of samples of wool from the half-breds and double half-breds showed that 60 per cent. of latter were free from kemp as against 27 per cent. among the former. The fleece of most of the double half sheep was fine, dense and of even quality, with

Breeding Ram, Mysore, Polled.

Breeding Ram (No. 5) and his male progeny.

Shoulder wool; Mysore Ewe.

Farm bred lambs; Mysore.

a certain amount of crimp in a few cases. A comparison of the wool clips has been made elsewhere in the note.

Sheep in other Countries a Comparison.—The Peruvian sheep approach that of Mysore in body weight. While in Australia about four acres are required per sheep and seven acres in South America, only one or two acres are sufficient in Peru. Our conditions are quite unsatisfactory requiring nearly eight acres per sheep with practically no grazing in such areas for three months in the year. The improvement in Peru is going on by the selection of the best ewes and mating them with pure Merinos or the best selected grade ones in out-of-the-way places. So, it is a grading up that has gone on very systematically.

Defects in Methods of Improvement Adopted Till Now.—In Mysore, half-bred rams, quarter-bred rams and rams of lower grade are being distributed for over 100 years with no attempt to cull out undesirable ewes and select the best ones for further improvement. Further, there has not been a continuous supply of Merinos and all attempts have been spasmodic and at very long intervals.

Future Development and Results Already Achieved.—The future development consists in adopting the latest genetic methods which we have already adopted in recent years after 1931, and we are trying to build up high grade stock on several lines of breeding utilizing what little material that is available. It is encouraging to note the general improvement in the flocks under observation and to note the appearance of a number of young lambs resembling almost the original type of the Merino but having more vigour and better body.

Sheep Survey in Mysore Essential.—So far no systematic work has been carried on to determine the different varieties of sheep to be found in Mysore and which of the types, if more than two types exist, is the best suited for propagation. Work done in the past has been influenced mainly on the consideration that as the fleece of the Mysore sheep is very poor it should be improved by crossing it with imported varieties, chiefly Merino.

History of Improvement.—Attempts to improve sheep were made almost a hundred years ago by importing Merino rams yearly from Australia and distributing the cross-breds, and the wool was being sent to England by Government for being manufactured into blankets and serges. In 1863, this activity ceased. In 1888, a flock of 15 rams and ewes was imported from Australia and there was no continuity of work until again similar activities began in 1918 under the control of the Board of Agriculture who imported a flock of 30 Dumba ewes and rams from the Northern part of India, and some Merino rams from Australia and carried on some operations in Gottigere near Bangalore. In 1920, the Department of Agriculture took over the activities in this direction by importing two Merino rams from New South Wales, both of which died within two months of their arrival. These were again replaced with two more in the same year and 52 ewes from Poona (Bombay Presidency) which showed a better fleece than Mysore sheep, were also imported. All these did not survive long enough and again in 1923, a flock of 6 rams and 6 ewes were imported with a view to breed pure Merino rams which may be more easily raised and be more amenable to climatic conditions than those imported as adults. Neither the adults nor their progeny survived long, the latter dying within six months of their births. In 1925, 3 rams and 6 ewes were imported. In 1927, 6 rams were imported and 4 more again in 1928. 4 rams were imported from South Africa in 1930, 2 rams and 3 ewes in 1932 and 3 rams and 3 ewes in 1934. The stock that now exists consists of 5 Merino rams and 3 Merino ewes.

Causes of Failure in the Earlier Stages.—For various reasons, cross-breeding experiments have not led to any substantial results in the earlier history of the activities on account of the spasmodic attempts made, and in the latter, on account of the following reasons:—

(1) Merinos or their pure progeny have seldom survived beyond seven months on an average. Adaptability is a great problem in sheep breeding. Attempts were made in other

Left: Farm bred Mysore Ewe. Right: Village Ewe 6 months' clip 8 ozs. 12 months' clip 17 ozs.

Merino Rams.

Double half Ram and Ewe and their progeny.

Yearlings: Sire Merino, Dam Double half Ewe.

Left: Mysore lamb. Right: Double half lamb.

parts of India to improve the wool by importing Merinos early in 1800 and again from 1912 the Civil Veterinary Department made similar attempts in Muttra, Mirzapur, Lucknow, Aligarh, Moradabad, Nainital, etc., by crossing Merinos with Bikaner and other local ewes, and no success seems to have been achieved.

(2) Limitation of pastures and want of facilities to adopt a rotational system of grazing.

(3) Loss on account of parasitic diseases, sheep-pox and other unidentified diseases among the crosses.

(4) Heavy culling from among the crosses on account of coloured progeny among the crosses.

(5) Delay in the Merino rams taking to the ewes extending even up to a year or more after their arrival.

(6) Illness and unfitness of Merino rams just about the breeding season.

(7) Insufficiency and inefficiency, or both, of the Merino rams.

(8) Period of drought.

(9) Unfruitful services.

(10) Casualties among the rams and non-arrival of fresh ones to replace them.

(11) Very poor funds provided by Government for the nature of work.

(12) Technical difficulties in obtaining the required amount to replenish foundation stock even though allotment existed.

(13) Wide prevalence of infectious diseases at the time when the replenishment was necessary.

(14) Difficulties of overcoming the prejudices of sheep rearers who are an ignorant and obstinate class.

(15) Non-filling of vacancies of Inspectors in charge of sheep work, inadequate trained staff and want of continuity of trained people in the same line of work.

(16) The ill-effects of the piercing of spear grass into the skin and even lungs and hearts of densely-woolled cross-breds.

On account of the above reasons, the work done is of much too restricted a character. Unless the policy of a farm wherein cross-breeding of ewes that are not pure for their white colour, or in whom definite characteristics have not been established by improving them in the first instance, is to carry a stock of 1,000 ewes, with a yearly production of corresponding number of half-breds, very few animals would be available for breeding on proper lines, in view of the large number that has to be culled, or that would die on account of various causes.

The experiments so far conducted have no doubt enabled the Department to supply a certain number of cross-bred rams and some slight improvements in individual herds are visible wherever enterprising owners have been able to get these rams, but, before a type is evolved, indiscriminate supply of rams to persons not trained in such work cannot prove satisfactory. Attempts have also been made to introduce dipping and machine shearing, but, owing to the difficulties involved and the absence of an adequate establishment to popularise such work, these attempts could not be made on a large scale.

Mutton.—So far as the bulk of the people is concerned, the price of mutton will be determined, more or less, by the price of goats which are more prolific and less susceptible to disease and easier to keep. Any undue prominence given merely to mutton improving side may lead to serious disappointment though there can be no doubt there will be appreciable increase of demand for such superior classes of mutton, especially among the better classes.

Wool.—In the case of wool, the requirements of the Indian weavers and the local mills have been kept in view. It may be possible to find a market even for Indian wool, especially if it could be improved and extracted by better method. Improvements of wool, therefore, should have some reference to the end in view, *viz.*, to supply a better product and increase it with reference to local requirement and gradually to take up the supply of other markets. The demand

Shoulder wool of double half Ewe.

Double half rams with and without wool on the belly.

Quarter bred Ram, horned.

Quarter bred Ram, polled.

for the indigenous wool has not been sufficiently organized just as in the case of the Indian cotton; a good market may be built up with a little more attention to proper commercial methods. For a long time to come, it may not be possible to change the nomadic character of the industry. It is true that in many villages, some of the villagers keep a certain number of sheep, but the difficulty of grazing in summer stands in the way of large herds being maintained in each village.

Consideration of Methods of Breeding.—We have been in touch with work on sheep carried on elsewhere, but it must be remembered that different environments can, within limits, modify the expression of the genetic constitution of sheep for wool production, but genetic constitution being fixed, cannot be changed by environmental agencies. It has been frequently pointed out by various authors that no simple Mendelian approach is applicable to a study of the various characters which together constitute the fleece, and that wool production by the skin of the sheep depends upon a multifactor system, whether the fleece is considered as a unit, or whether the study includes only one, or a combination, of its various physical attributes. Standardized environmental conditions have been shown by many workers to be essential in any experiments where wool characters are involved. For various reasons, the stock that is being dealt with has had to be frequently shifted 100 miles apart, and the allotment, when some good progress has been achieved, has dwindled down to one-third of what it was when the Department of Agriculture took up the work on hand. It is permissible to consider that in a great majority of cases the phenotype behaves in breeding as a genotype, even though it may not be identical with it. Selection has to be based on factorial constitution and continued selection for the perpetuation of improved characters and progress depends upon the availability of large numbers.

Breeding Stations.—The Yellachihalli Sheep Farm is located 12 miles away from Mysore. It is about 400 acres in

extent and is situated on a high level with small hillocks round about. This was started in 1921–22, and the first few years were spent in clearing the area of lantana and shrubs and putting up temporary structures for accommodating sheep, constructing a well, etc. These temporary structures were later on re-erected in a permanent manner by diverting funds from the allotment for running expenses.

The average rainfall on this farm is about 28 inches. The pasture consists mostly of spear grass.

The policy of breeding now adopted is to study the indigenous types of sheep of the State, their rearing, breeding, and improvement. As it is a matter of fundamental importance that definite characteristics be made the starting point in selecting suitable types of ewes for foundation stock purposes, the ideal aimed at is the sheep that will develop the largest frame possible, and to pack on that frame, a type of wool having length, colour, character and density. In addition to this, attempts are being made to maintain a pure-bred homozygous type of local sheep. Selected ewes bred to Merino rams are stationed here, and the F_1 progeny is transferred to Ajjampur for further work. In improving the local sheep from the point of wool, the mutton quality is not neglected. Arrangements are also being made to test the fibre qualities of various types of Mysore sheep.

The local breed on this farm has been improved both in covering as well as formation by careful culling and classing. As regards the quality of the fleece, the staple length is on an average 2½ to 3½ inches, and almost 70 per cent. of the fleece consists of wool fibres and the rest consists of heterotypic fibres and a very negligible quantity of kemp. Though some of the local sheep produce a staple length of nearly 6 inches, the wool is coarse and full of kemp.

Attempts to establish a definite breeding season instead of an all-year round breeding season were made on this farm, and it was found that lambs born in October-December season do better than those born later, as the ewes seem to lamb with

Quarter-bred Ram, lamb.

Five-eighth-bred Ram.

1. Local. 2. Half-bred. 3. Quarter-bred. 4. Double half-bred. 5. Merino.

1. Merino. 2, 3 and 4. Variations in improved village flock, Sabbanahally.

heavier flow of milk in that season. With a view to increase the percentage of lambs over the average number of ewes, the breeding operations were spread over two seasons—April-June and August-October. So far as increased production is concerned, this system is advantageous in so much as that such of the ewes as happen to be unfit to take the ram in one season, could be bred in the next, within a short interval, and such of the rams that become unfit to function in one season are better fitted to serve such ewes as could not be bred either on account of their not having come into heat, or on account of their number being too large for any one ram. The advisability of continuing this policy depends upon the development and rate of growth of lambs, and the density, quality and rate of growth of wool and its kemp content.

It may be safely said that the incidence of stomach worms in lambs is one of the most important economic problems in sheep farming. As shifting of lambs on to fresh pasture as frequently as possible, which is the best preventive measure, is not possible on account of limitation of pasture, sheep on this and the two other farms were fed on concentrates throughout the year. It is found that improved nutrition renders the sheep more resistant to infestation. Special sheep fodders and foliage crops are raised on this farm for study and experiment. The economical aspect of feeding sheep with such fodders and foliage that can ordinarily be grown and easily adopted by the raiyats is not ignored. Special crops like soya beans, sun-flower, field beans, pod-bearing trees, like *Algeroba* and *Accacia Arabia,* are grown to supplement pasturage.

The second farm is located at Ajjampur, Kadur District, as a subsidiary to the Cattle Breeding Station. The average rainfall on this farm is 32 inches. As the pasture is richer and the soil contains much lime, observations are being made to see if sheep would develop better.

(1) The Mysore selected white sheep are bred to Merino rams and sent over to the Yellachihalli Farm.

(2) The F_1 progeny born at Yellachihalli are transferred here after weaning and reared.

(3) F_1 rams and ewes are graded and grouped according to quality of wool and other characters, and by interbreeding in the groups F_2 progeny are raised for evolving homozygous types with all the desirable qualities.

(4) Some of the best F_1 ewes are bred back to the Merino to see if by these back crosses and through rigorous selection of rams and ewes, it would be possible to raise homozygous Mysore Merino type by a shorter method.

(5) All the rejected stock from F_1 and F_2 are transferred to another station, 9 miles off, and are bred to Merinos. Out of this progeny, a rigorous selection of ewes is made for further inbreeding to see if pure Mysore Merino type could be evolved. This method, while insuring the rejection of a large number of cross-bred stock from critical experiments, affords a stock of ewes, superior to local ewes for further breeding with the Merinos. It also saves the cost of purchasing pure white stock of local white ewes for breeding experiments.

The third farm is located at Hebbal, five miles from Bangalore, where the average rainfall is about 30 inches. A very small flock is maintained here for instructional purposes to the Agricultural Students.

The rams and ewes of F_2 generation selected for inbreeding are transferred to this place for critical observations as the place is very near to the Live-Stock Expert's Office, and there are facilities for such kind of work. At the same time, this gives ample opportunities to the students to study the hereditary transmission of characters.

The results obtained in the breeding experiments, and the observations made in the various crosses are generally studied in the Departmental Central Laboratory. It is also hoped to study in detail the wool of the various selected rams and ewes and make microscopic studies in future. Every attempt is made to keep detailed records by means of photographs for future reference and guidance.

A further attempt is made to make a detailed study of the phenotypic and genotypic characters of the various crosses for further breeding work.

Trade.—The condition of the woollen trade affects both the sheep rearers and the local *kambli* weavers. Of the latter, the State possesses, according to the last census, 7,500 families. With a larger and larger dumping at very low prices of outputs from Italy and other foreign countries, the two classes of people, *viz.*, the rearers and the weavers, are hit hard and are impoverished. The competition of these cheap carpets compels the weavers and the local mills to offer a much lower price for the local wool and the sheep rearer hardly finds enough incentive to maintain any large flocks.

The sheep rearer has also another competitor as far as his wool is concerned, *viz.*, the tanneries which sell carcass wool. The result has been a large reduction of the hand-looms in the State and the consequent loss of occupation to many a *kambli* weaver.

The wool from local sheep is chiefly used by the *kambli* or blanket weaver. The local weaver cannot pay any high price for the wool and though exports may be advantageous in certain respects, it affects the local industry. Very little wool is imported from foreign countries. The imports into Mysore are from the neighbouring parts of British India and Hyderabad, and to some extent from Northern India, but these are all consumed by the local mills. The villagers make their own yarn. It will be advantageous to induce them to use mill-made yarn, but there is great difficulty in marketing increased production which leads to accumulation of goods among the weavers who cannot wait to secure a good price. Government requirements furnish a more or less steady market, but these are all monopolised by the mills. If the villagers are to use mill yarn some organization should be provided to make the villagers get a part of this demand.

It is not possible for Indian mills to manufacture all the different varieties of cloth required in India, as this requires much specialised machinery. The market being limited, mills

cannot afford to equip themselves with all such machines. At present, the local mills chiefly specialise themselves on the manufacture of rugs and blankets. Foreign competition has already encroached upon this field and a cheap type of blanket to compete with the village-woven *kambli* has been introduced into the market. Unless adequate protection is given, local production is bound to decay but, in giving protection, care should be taken to see that the *kambli* weavers are not sacrificed in the interest of the mills and the revenue derived from protection should be substantially applied for improving cottage industry and if there is any unfair competition on the part of the mills, even an excise duty will be justified.

The articles prepared by the villagers are very coarse. They use very inferior wool; moreover, the preparatory processes are all primitive and the blankets, which are very strong and durable, lack in finish. Consumers will not rest content with the coarse fabrics now available even in villages and the articles prepared by the villagers should meet the changed standard of taste.

The improvement and stabilization of the woollen industry in India, therefore, depends upon several factors. The first place should be given to the interest of the village producer and consumer, by giving protection against the imports of blankets and rugs of cheap variety and specially those made from shoddy wool. The supplies of wool should be increased by improving the quality of the sheep. The villagers should be taught improved processes of manufacture and suitable facilities provided for marketing the goods. The mills should be encouraged to produce goods on a mass production basis but so as not to compete with village industries and, if necessary, a heavy tariff is to be imposed to prevent foreign competition, but it is essential that any increase arising from this source should be primarily utilized for improving the industry. As regards other articles, there is no objection to adopt a high rate of duty as they are consumed by people who can afford to pay a high price, and they do not in any sense contribute necessities in a country over the greater part of which warm clothing is not required.

SELECTIONS

Is it Possible to Ascertain whether Ewes or Goats are Pregnant by Examination of the Urine ?

Much attention has recently been paid to the possibility of ascertaining whether the gestation period has begun by an examination of the urine and the blood, and their content in sexual hormones. Although the method is not yet absolutely reliable, a certain precision has been reached in the case of horses. The biological method of Zondek and Ascheim has not yet given reliable results with regard to cows. W. Maurer has made investigations for the purpose of ascertaining whether some degree of accuracy cannot be attained by applying this method to ewes and goats. He examined 6 ewes and 6 goats at the Berlin Animal Husbandry Institute and discovered that it does not give satisfactory results. The examination of the blood might still be considered, but it would be difficult to obtain suitable material for experiments.

—*International Review of Agriculture,* March 1934, Vol. XXV, No. 3.

FARMERS' LIFE

Prince of Wales on Their Difficulties

The Prince of Wales spoke from experience of the practical difficulties of a farmer's life when he received at St. James Palace 200 representatives of County Committees of the Royal Agricultural Benevolent Institution, of which the King is Patron and the Prince Vice-Patron.

To mark the institution's 75th anniversary, the Prince handed to Lord Eltisley, Chairman of the Executive Council, a Royal Charter from the King in Council.

The Prince said that it would be a disastrous day for the country if the rich heritage of its agricultural lands, on which the finest type of manhood had been raised, were allowed to suffer wastage or neglect through the difficulty of maintaining the industry on a safe and prosperous footing.

He added: "My experience of the farming industry derived from my Duchy of Cornwall and my ranch in Canada, has taught me a good deal of the practical difficulties of a farmer's life. No one who has moved among agriculturists, as I have done, can fail to appreciate the very precarious nature of their calling.

"The farmer is probably the most beset with difficulties of any man engaged in industry. He never knows what the morrow will

bring forth, for, in addition to his economic troubles, he has always the uncertain forces of nature to contend with. Accidents of disease among his stock or a disaster to his crop can, in a period of agricultural depression, easily exhaust a slender capital and complete the ruin of a life-time's work."

—*The Hindu.*

Examination of Samples of Indian and Foreign Coriander (*Coriandrum sativum*)

This investigation on coriander was undertaken at the instance of the Imperial Council of Agricultural Research, with the object of elucidating the factors responsible for the low price commanded by the Indian products as compared with that of other countries, in the Ceylon market. It was understood from the Ceylon Trade Deputation of 1933 that Indian coriander, as imported into Ceylon, was considered much inferior to Moroccan coriander seed and that Indian coriander fetched about Rs. 35 per candy as against Rs. 50 for the Moroccan produce. The deputation also expressed the opinion that the Indian supplies were often badly cleaned and full of stalk and were of doubtful flavour and quality.

The Imperial Council of Agricultural Research collected samples of coriander from different sources—Indian and foreign—and sent them to one of the authors for examination. The scope of the investigation comprised the following:—

(i) General study of the samples and the quantitative estimation of their purity.
(ii) Grading in terms of size and weight.
(iii) Estimation of matter soluble in petroleum, ether and rancidity of the extractives.
(iv) The determination of their essential oil contents.

* * * *

Conclusions.

In the light of the data collected in the course of the comparative study of the samples, the view that Indian coriander is of doubtful flavour compared to the Moroccan does not stand the test. For, the essential oil content of the Indian being equal to the Moroccan, if not higher, the Indian produce has a better flavour than the Moroccan. Perhaps the attractive appearance of the Moroccan coriander as against the dull and oval nature of the seeds of Indian coriander, may be the probable reason for the preferential treatment offered to the former. The statement that the Indian produce is "unclean" is amply warranted by the Tuticorin sample examined in the course of this study, but the doubts in regard to flavour are unfounded. The result of examination

of a sample of Indian coriander obtained in Udamalpet market, in the Coimbatore District, clearly shows that the producer and the local market are free from blame for the unclean and impure product represented by the Tuticorin sample. If the Indian produce can keep up the quality of that obtained from the local market, taking all factors to account, it should be able to realise a higher price than the Moroccan coriander.

—*Agriculture and Live-Stock in India,* Nov. 1934, Vol. IV, Part VI.

Mr. Souter on the Role of Specialist and Interdepartmental Co-operation

The following report of the speech delivered by Mr. C. A. Souter, Revenue Member, Madras Government, presiding over the 24th College Day and Conference of the local Agricultural College, is taken from *The Hindu* (daily) of Saturday, August 3, 1935, and is extracted here as containing suggestions of common interest:—

Mr. Souter, in the course of his address, said that certainly in the next few years the Madras Presidency would have full control of itself and naturally it seemed to him that the various departments would begin what was going to happen in the future and to order things accordingly. It seemed to him that the Agricultural Department was at least the one which must expand and expand and in future this department was going to have a very large say in the prosperity of that province. Continuing, he wanted the students to remember that in this world what ruled was competition. He cited the instance of Cochin-China being able to sell their produce of rice in our market at a price at which the local dealers themselves could not sell theirs and suspected a radical reason for that. If their agricultural methods were thought to be better, it was up to the students of agriculture here to bring the agricultural methods of this country to the same level as that of the other. Speaking of research and field-work, he said that here it was the duty of those amongst them who were specialists, particularly in the Agricultural College, to give their results in easy palatable and well understood form to those amongst them whose duties took them to the field and who had not the leisure to study for themselves. The specialist ought to be able, he said, to send round to all the members of the Agricultural Department a precis or resume of his work and results and ask that his conclusions should be tried out and here again it was an easy matter for the man in the field to carry out experiments on lines laid down by the specialist.

There was only one other point, continued Mr. Souter, which he would like to refer to. When he first came out to India, the Collector

was looked upon as a sort of power almighty in the district. All departments went to him for assistance and his advice was freely given and he had some actual control over the working of practically every department in the district. As they all knew, gradually that system had been dissipated and now-a-days there was, to his mind, a very unfortunate tendency for each department trying to work by itself. The result had been, of course, that the Revenue Department did not know what the Agricultural Department was doing, the Irrigation Department did not know what the Revenue Department was doing, the Forest Department had no idea of what the Agricultural Department was doing, and so on. It seemed to him that even as in former years, a sort of return to the old system was desirable. He did not for a moment say that the Collector should have an easy say in the actual working of the department. Far from it. He had far too much work to do himself. But it did seem to him that the representatives of the various departments in the district might, with great advantage to themselves and certainly with advantage to the Collector, go and consult him and ask his advice and, if necessary, his assistance. He should like that even the scientists, who might think, probably rightly, that a mere revenue officer knew a bit of the administration and precious little of the growth of a plant, might go to him who, with his varied experience, would help them in carrying out their experiments far more than they imagined and, if they could get his sympathy on their side, and his co-operation, their experiments would be far more successful than it would otherwise have been. He thought that in particular, the Agricultural Department ought to be in close touch with the Collector. He commended to them the suggestion that they should, as far as possible, endeavour to have a discussion on a problem of theirs and ask his help.

Potato Growing in Victoria*

No. 4. Plant Food Requirements.

BY

J. T. Ramsay, *Potato Expert*

In all fertile soils most of the plant foods necessary for successful cropping are present in sufficient quantity, but, frequently, it is necessary to add to the soil one or more of these plant foods if maximum yields are to be obtained. The elements most generally deficient are phosphorus, nitrogen and potassium. There are two ways by which the

* For previous articles on this subject *vide* Vol. 13, No. 3 and Vol. 14, Nos. 1 & 4.

supply of these plant foods in the soil may be increased for the benefit of crops, namely—

(1) By applying organic matter as green or stable manure, and
(2) By the application of artificial fertilizers.

Green and Stable Manures.

Green manure is the name generally given to a crop which is grown specifically for the purpose of being ploughed under, to enrich the soil from the chemical and bacterial standpoint, and to improve its physical condition. Stable manure, of course, consists of the excreta of animals, and may or may not be combined with any material used as litter or bedding, such as straw, etc.

Both green and stable manures have a high value because of their effect in increasing the organic content of the soil, an effect particularly important in districts with a dry summer climate. Inorganic chemical manures supply plant food either directly, or in an easily convertible form, without adding to the organic matter or humus content. This difference between natural and artificial manures can be better appreciated by reference to the previous article on the importance of good physical condition of soil for the potato crop.

Owing to the fact that continuous housing of stock is not practised in this State, farm-yard manure is not available for application to land in sufficiently large quantities to treat large areas. Even at the present time, market gardeners, who operate mostly in proximity to large towns, where many animals are stabled the year round, have difficulty in obtaining sufficient quantities for the requirements of their comparatively small areas. Consequently, where organic matter or humus is scarce, reliance must be placed on the growing and ploughing under of crops for green manure. Already there are certain potato districts in Victoria the soils of which, through constant cropping, have become practically depleted of vegetable matter. Soils in this condition are difficult to work and maintain in a condition of good tilth. They are consequently expensive to operate, and considerably reduced in moisture-holding capacity. They set into a "packed" condition readily, and seldom produce tubers of good shape except in very wet seasons. Until green manuring is brought into general practice on such lands, their physical condition cannot be efficiently improved.

There are various crops which, because of their comparatively low cost of production, and their capacity to produce in material quantity the essentials required for soil improvement, are suitable for employment as green crops. The principal of these are, in order of importance, rye, peas, oats, barley and mustard. All of these are good individually, but probably the best green crop is a mixture of rye grain and peas

sown at the rate of 1¼ bushels of rye and ¾ bushel of peas (ordinary dun) per acre. This combination has in its favour the capacity of the rye to produce an immense bulk of green stuff to the acre, in conjunction with the capacity of the peas to build up the nitrogen content of the soil. Mustard is a very useful crop for use as green manure, but care must be taken not to allow it to go to seed, otherwise it is likely to become a pest. Its particular value lies in the quickness of its growth, which allows of its being usefully employed where time does not permit of the growth of a heavier-producing but slower-growing plant. It should be sown thickly, say, 20 to 25 lbs. to the acre. At this rate of sowing, and given good weather conditions, it will smother almost any weed, and leave the land in a clean condition.

The most suitable time to plant mustard is spring, for the following reasons:—If sown in, say, late August or early September, it should be ready for ploughing down before the end of October. Owing to its sappy nature, it soon decays, and will be ready for the late November and early December planting, which is the time of planting of the bulk of Victoria's late potato crop.

The rye and pea combination, as well as oats or barley, should, of course, be autumn sown, the earlier the better. The best time to turn under the rye and peas is when the shot blade in the rye makes its appearance. At this stage, the plant has attained considerable bulk, and is about its highest degree of succulence. This succulence is important, as, if turned under at that stage, decomposition follows very quickly, which is desirable. No difficulty need be found in the complete burial of the rye and peas if a mould-board plough is used.

A moderately light chain should be attached to the near end of the plough rack, of sufficient length to reach beyond the tail of the mould board. This chain, dragging in the furrow, with the weight of the overturned soil on it, curls in the green stuff growing on the sod, and effectively covers it. Should the weight of the chain of itself be insufficient to effect the covering, a plain elongated iron weight can be attached to increase the drag. Rolling after ploughing in green stuff is helpful in hastening its decay.

It should be stated here that if the stems of the rye are allowed to become too dry and fibrous before being ploughed in, the object for which the crop was grown will be defeated, particularly if the weather following ploughing be dry.

In all cases, where a crop is sown for use as a green manure, it should receive 1 cwt. or 1½ cwt. of superphosphate per acre in order to promote rapidity and volume of growth.

Occasionally growers have ploughed under what was practically a straw crop, with most harmful results when a dry season followed,

In such cases, insufficient moisture was present to permit the decomposition of the straw, and the land remained puffed up with this bulk of dry material, to the detriment of the potato crop following.

Formerly a grass and clover mixture was considered an excellent green manure for a potato crop. Unfortunately, however, clovers form an admirable host for eelworm (*Heterodera radicicola*), which has spread so much in late years, and which so seriously affects potatoes. For this reason, it is generally inadvisable to follow grass and clover with a potato crop.

A comparative analysis of farm-yard manure and green rye is given below:—

	Per ton of farm-yard Manure.	Rye.
Nitrogen ..	10 to 15 lbs.	7.8 lbs.
Phos. acid ..	4 to 9 lbs.	4 lbs.
Potash ..	9 to 13 lbs.	16 lbs.

The variations in the quantities of the nutritive elements in farm-yard manure are influenced by the class and age of stock, the kind of feed used, percentage of straw, etc.

—*The Journal of Agriculture, Victoria,* Vol. XXXI, Part 7.

(*To be continued*)

Preliminary Observations on Coffee Roots in Kenya

BY

A. D. Trench, *Senior Coffee Officer*

Perhaps in all coffee-producing countries, it has generally been accepted that the tap-root, described as the most delicate organ of the coffee plant, can be the source of all evil. This view has almost entirely been based on observations conducted on unhealthy plants, dug out by implements.

Recent observations on root systems, carefully removed by washing, would, however, seem to point to the advisability of giving only a qualified acceptance to this belief.

In the past, we may have assumed too readily that the trouble was inherent in the tap-root; whereas the deciding factor may rather have been the soil conditions encountered, not only by the tap-root, but by the several vertical roots originating in the forking of the tap-root. It is not proposed to expound or make any suggestions as to the causes why one plant should have a much better developed root system than another, any more than to suggest reasons why one child of the parents is more healthy than another, but I would like to emphasize the fact that the well-being of both can be materially affected, not only by environment

but by wise guidance and treatment suitable to their particular shortcomings. In this connection, Plate No. 1 demonstrates an excellent root and Plate No. 2 shows a very poor vertical root system. Both are three-year-old plants. In time of drought, No. 1, because of drawing its food supplies from the deeper and moisture-containing strata of soil, could support its aerial growth much more efficiently and for a longer period than No. 2, drawing its supplies from a superficial layer readily denuded of moisture. Further, the root system shown in Plate No. 1 has, of course, a far larger area to draw upon than that shown in Plate No. 2.

In view of the fact that a healthy and well-developed coffee bush does not appear to possess a long and tapering tap-root, it is clear that the health of the coffee plant is not dependent on a tap-root, which is usually well defined in young sapling.

What appears to be essential are well developed laterals and vertical roots; the latter being most important during periods of drought. Therefore, to attain this, every encouragement should be given to the root development from the moment of planting out in the field. It is considered that a clear case has been established for increasing the size of the hole, also to continue, as planters have done in the past, nipping off the thread-like portion of the tap-root before planting saplings, as this will tend to encourage the vertical root spread. The following extracts from a book entitled *Recent Advances in Plant Physiology*, by Mr. E. C. Barton-Wright, so coincides with recent observations made by the writer that they are quoted (the authors to whom reference is made are Messrs. Weaver, Jean and Crist) :—

"In the light of their investigations these authors considered that the statements made in agricultural literature to the effect that only the surface soil layer is used by roots for absorption and that the lower sub-soil only plays an indirect part need to be very considerably revised. In every case where the roots of plants were excavated, the sum-total of the development below the cultivated soil surface layer was as big as, and in some cases even bigger than, in the surface soil. The dependence of the plants on these more deeply-seated layers becomes prominent in times of drought. At such times the vegetation remains unwilted and fair yields are still obtained from the crops when the surface layer is practically exhausted of moisture. In every case in which the roots came in contact with a fertilized layer, they showed extensive development and branched vigorously, but normal extensions into the deeper layers were checked. An important general conclusion arrived at by the authors is that manuring the surface layers of soil where precipitation is small and conditions of drought are ever present is detrimental to crop growth."

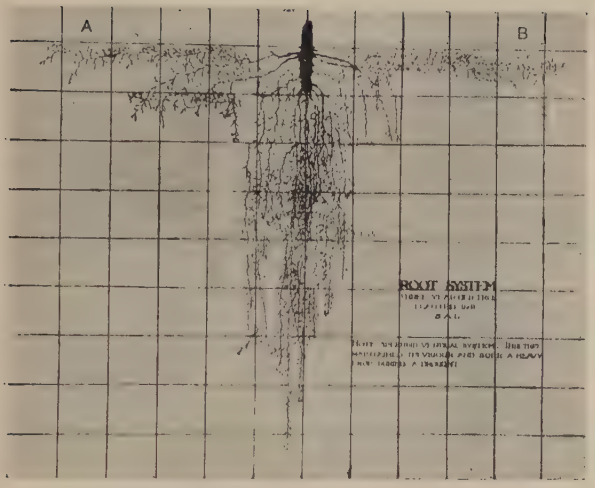


Plate No. 1.

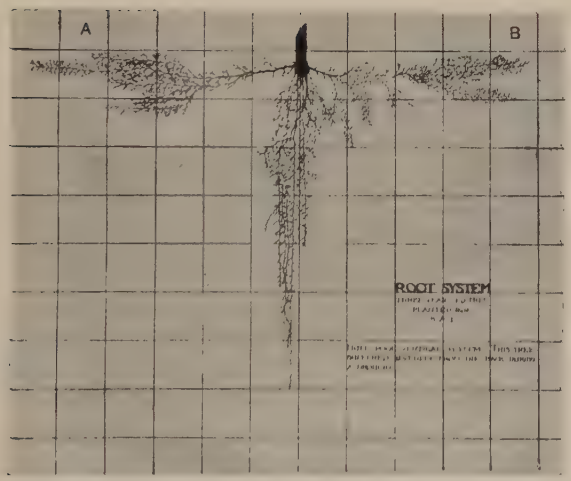


Plate No. 2.

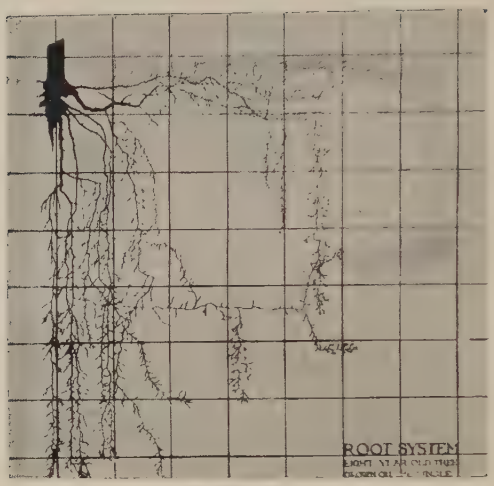


Plate No. 3.

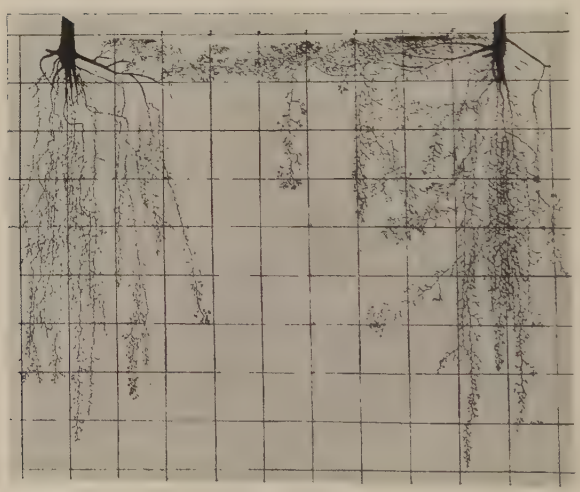


Plate No. 4.

The chief point to be stressed here is that the root system is not static, and that any manurial and cultural measure must of necessity be adapted, not only to the existing root system, but to the desired development.

In the past, it has been the general principle to regard the coffee plant entirely as a surface feeder, to the detriment of its complete root system. For example, in Plates Nos. 1 and 2, the obvious treatment is to extend the surface roots while at the same time encouraging them to find depth. For this, the most economical method would be trenching down the centre of the rows of coffee at the points A and B, or better still, sub-soiling and applying organic manure utilized, which would be effected and all available moisture utilized, which would not be possible with a more intensive method such as pitting. On the other hand, when the soil is obviously poor and exhausted, it will be evident that the proper treatment is, firstly, sub-soiling and deep-manuring, in order to develop deeper roots and bring into use the soil moisture in the lower layers, and then concentrate on building up the humus content of the surface soil.

Plate No. 3 illustrates a well-developed lateral root which is growing vertically into the soil in the centre of the row, no doubt resulting from the sub-soiling carried out some years ago.

In Plate No. 1, it will be observed that no attempt has been made by the lateral roots to turn vertically into the soil. It is possible that they will eventually do so, but why not encourage them in their early youth to find depth, at which period deep forking on sub-soiling could be carried out without causing any material damage to the lateral roots?

Plate No. 4.—In Plate No. 4, it will be noted that root development of tree X in the vicinity of the stem is very poor, whereas in the case of tree Y the surface roots are well developed. The explanation of this is that in the former the root-hairs have been removed in cleaning under the tree in order to study the leaf fall. The ground under the drip of the tree was periodically raked and this treatment damaged and checked the surface root growth. In the case of the latter, the root growth under the drip of the tree was left undisturbed resulting in marked development of surface rooting. From these examples, it will be realized how important it is to exercise care when weeding under the drip.

Plate No. 5.—Plate No. 5 illustrates a poor and congested root system. The trees were planted 8 feet by 4 feet with the intention of digging out the alternate trees after harvesting a couple of crops. The illustration on the left of the Plate gives a good idea of what happens to the lateral roots when close planting is adopted and left so indefinitely. It is quite obvious that the intermediate plants should be removed. In the wetter districts this close spacing would not be so

detrimental as in a dry district from the point of view of moisture competition, *but, in any case, this close spacing is not advocated from the point of view of the incidence of disease and pests.*

The surface rooting illustrated in Plate No. 6 shows the effect of heavy applications of organic manures on the surface which could be produced also by thatching. This is one of the root systems washed out by Mr. Nutman, of the East African Agricultural Research Station, Amani, during his visit to Kenya in November 1932.

In recent years, certain authorities have strongly advocated a system of rigid abstinence from any form of cultivation of the soil on the ground of possible damage to the surface roots. This is a case when it is considered that the treatment may very well be worse than the disease. In this connection, it may be opportune to quote the following extracts from *Bulletin No. 13* of 1932, "Coffee Pruning", by A. D. Trench and S. Gillet:—

"The opportunity will be taken here to deal with what is regarded as maltreatment of the surface-feeding roots of the coffee bush. Unfortunately, severe root pruning is too frequently carried out in Kenya by the use of such implements as disc harrows, ploughs, etc. In the light of experience, the most satisfactory method of cultivation is by hand. The actual technique will vary and the methods to be employed during the different seasons of the year must be left to the discretion of the planter. The use of fork jembies is to be encouraged, but as there is a right and wrong time for deep cultivation to be carried out, fork jembies would not necessarily be used at the period of the year when the trees are bearing a crop. It will be appreciated that during the period when there is rapid formation of root hairs, the plant will be deprived of nutrients from the soil if root pruning is done by mechanical implements or by hand labour."

It is important that planters should study the period of root growth on their respective farms, in order that the cultivation measures be carried out at periods when there is no active root growth. As free oxygen is an absolute essential to the formation of nitrate in the soil for the growth of any land plant, its entry as well as the distribution of nitrifying bacteria is surely best facilitated by judicious cultivation at the appropriate periods. In the same way, the growing of green manure and cover crops, apart from directly improving the soil fertility, play, through the penetration of their roots, a very important part in soil aeration.

Vertical forking as a method of cultivation has only recently been introduced into Kenya. The vertical fork may be used to advantage to incorporate into the soil surface applications of manure and also to aerate the soil where thatching is carried out. In order to provide against any misunderstanding it is considered that, when advice on

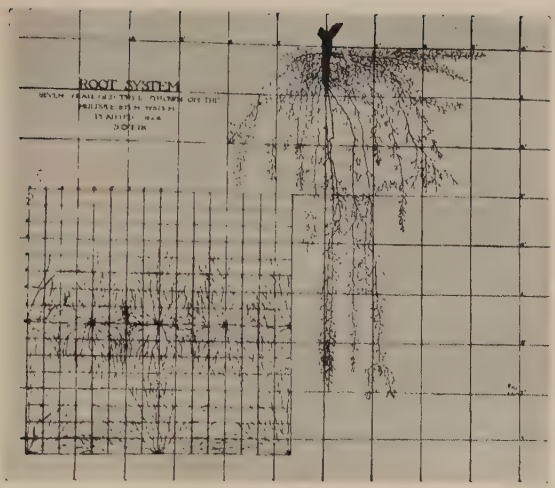


Plate No. 5.

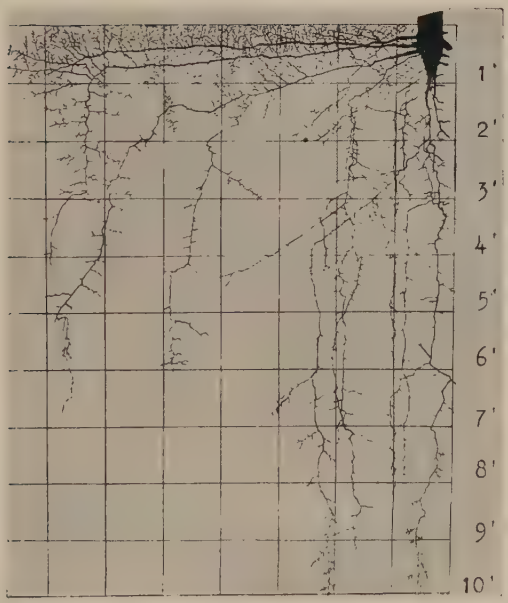


Plate No. 6.

organic manure is sought, the method of cultivation that is being adopted should be described. For example, for a planter who cultivates regularly with disc harrows, no useful purpose would be served by advising a surface application of manure.

Having dealt with a method of manuring, which might be adopted in order to encourage roots to find depth, more particularly in a dry district, it might be of interest to mention a method of encouraging surface-rooting by means of thatching, which method plays an important part in moisture conservation. If thatching is adopted, it is necessary that surface soil should be at a high level.

The risk of damaging a large area of coffee by fire may be minimised by having a fire-break of about five rows of coffee between the thatched sections.

In the drier districts planters should give more consideration to deep manuring or to thatching.

To conclude, in the case of new plantings, no particular roots should be developed to the detriment of others, but an attempt should be made to establish the whole root system by judicious manuring. In established coffee, each individual case must be taken on its merits and the method of treatment so designed (in the most economic manner) that the quickest response in the shortest time is obtained, with the ultimate object of establishing what might be considered a "general utility" root system.

I should like to take this opportunity to record my appreciation of the help which I have received from Mr. Gillet and Mr. Green, of the Scott Agricultural Laboratories, in connection with the work entailed in washing out the roots, and which have been so excellently drawn by Mr. Green for publication in this paper.

—*Bulletin No. 2* of 1934, Colony and Protectorate of Kenya Department of Agriculture.

The Coffee-Planting Industry in South India

BY

L. C. Coleman

Although in recent years coffee has had to give way to tea as the most important plantation industry in South India, it still retains an importance which cannot be estimated upon the basis of acreage or value of crop only.

The coffee plant was introduced to the west coast of India from Arabia during the latter part of the seventeenth century and into Mysore State, according to tradition, by a Muhammadan pilgrim returning from Mecca early in that century. It remained insignificant, being grown

by Indian cultivators in small patches, until the first part of the nineteenth century, when, through European capital and energy, the beginnings of a plantation industry were made in practically all the important coffee districts and in others where, during the past thirty or forty years, coffee has largely been replaced by tea. The industry developed very rapidly towards the end of the nineteenth century, and in 1896 an area of 304,447 acres was officially reported to be under coffee in Madras Presidency, Coorg, and in the Indian States of Mysore, Travancore, and Cochin. The peak of the industry, however, as judged by export figures, was reached much earlier, as the exports of 1894–95 were only a little over one-half those of 1871–72.

The early estates were, for the most part, opened up in regions of heavy rainfall, and many of the pioneers, who had had previous experience in Ceylon, introduced the Ceylon methods of clean weeding and growth in the open, but with disastrous results. Many of these estates, heavily attacked by white borer, leaf-disease, and green bug, and with their surface-soil rapidly removed by wash, soon ceased to pay, and were either abandoned or the coffee on them was replaced by tea. These factors, along with a slump in prices, reduced the reported area in 1919–20 to 116,411 acres. Since then there appears to have been a gradual increase. The statistics of coffee acreage are anything but accurate, and frequently the area reported to be under coffee includes unplanted jungle. It seems, however, fairly certain that the present planted area in South India is around 150,000 acres, of which about one-half is in Mysore State.

It would be unsafe to attempt to predict the future of the coffee industry. Now, when agriculture in general is passing through a period of profound depression, there is certainly no evidence of any rapid expansion in area. There are, however, indications that, with a return to more normal conditions, development will start afresh. For one thing, the trials of *Coffea robusta* during the past twenty years, more especially in the lower elevations where through the prevalence of disease and other causes the growing of *Coffea arabica* has ceased to be profitable, leads one to expect the development of a very considerable area under this more vigorous species. Further, the breeding-experiments of the Mysore Coffee Experiment Station already hold out great promise of producing much more vigorous and disease-resistant strains of *C. arabica* and of hybrids, which should make the growth of coffee profitable under much more varied conditions than is possible at present.

Notwithstanding its present comparatively small area in South India, coffee has still a much wider territorial range than tea. Moreover, the fact that its preparation for the market requires a very small expenditure of capital for machinery has left it pre-eminently as the

plantation crop for the small individual grower, as opposed to the large company. This is very striking in Mysore State, where a large part of the total area is cultivated by Indian planters owning individually 25 acres or less. Even the estates of European planters are small compared with those in some other coffee-growing countries, an average size being perhaps between 200 and 300 acres.

C. arabica, which has been heretofore the only species cultivated on a plantation scale, has been gradually replaced by *C. robusta* at the lower elevations and in the districts most subject to disease. This replacement is still going on rather steadily, and it seems probable that the area under coffee may expand by the planting of *C. robusta* in districts where coffee is not now being grown at all.

Coffee is confined to the hilly areas of comparatively heavy rainfall comprised in the Western and Eastern Ghats and their offshoots. Attempts made some years ago to grow coffee under irrigation in areas of low rainfall, such as Bangalore in Mysore State, ended in failure. Successful plantings have almost invariably been made on what was originally fairly heavy jungle, although cases are not wanting of successful estates, or parts of estates, having been developed on land under scrub jungle or even grass.

As might be expected from its comparatively wide distribution, coffee is grown under very varying conditions of elevation, soil, and rainfall. In the Mysore State, for example, the elevation of coffee estates varies between 2,500 and 4,500 feet, the higher elevations being the more suitable in respect of quality crop, freedom from disease, and average yield. In the Nilgiris and the Billigirirangans, coffee is grown up to 5,500 feet, but at such high elevations it has, for the most part, been replaced by tea. In two other important coffee districts, the Shevaroys and the Annamalais, the elevation is between 3,500 and 4,000 feet.

The rainfall in coffee districts varies widely both in amount and distribution. In the western districts of Mysore and Coorg, the rainfall is largely confined to the period of the south-west monsoon, June-September, though blossoming follows the first showers in March or April, which succeed drought conditions lasting 3–5 months. The more easterly districts receive much more rain, which is derived from both the south-west and north-east monsoons. The annual rainfall varies between 50 and 150 inches. High rainfall of over 100 inches is, in general, considered unsuitable for coffee, but that is, I believe, largely because it is usually associated with severe attacks of such diseases as black rot, leaf-disease, and dieback. With the methods of disease-control recently introduced, there seems no reason why *arabica* coffee should not be grown with profit in many areas where it has been abandoned largely owing to conditions associated with heavy rainfall.

Whereas the common types of soil are the red gravelly loams characteristic of much of the wooded areas of our hilly regions, we also find considerable areas under fairly stiff clays, and others characterized by large amounts of rock outcrops. On the whole, however, a friable loam, well supplied with humus and allowing of easy drainage, may be regarded as the most suitable for coffee. The development of more hardy strains and varieties and the introduction of *C. robusta* are likely to extend very considerably the choice of soils for coffee cultivation.

Early Scientific Work.

The earliest strictly scientific work on coffee in South India was that of Lehmann, who, during the period 1898–1908, started work on the manuring of coffee and the factors determining quality. Work was continued by Anstead, and results of great value were obtained, although the lack of plots under the direct control of the investigators was a great handicap. This was remedied in 1919 by the establishment of a small experiment station at Sidapur, in Coorg, which was under the charge of Anstead until 1922 and afterwards under Munro. This station closed down in 1926, and a year after the Mysore State Coffee Experiment Station was founded at Balehonnur in the Kadur district of Mysore.

In the earlier period the Planters' Associations of Mysore and Coorg appointed two assistant scientific officers to work under the direction of Anstead. The longer of these appointments lasted for about five years from 1912, and the principal achievement was the study of spraying against black rot by Frattini. Anstead's earlier work was mainly of an advisory nature, but he found time to investigate with Pittock the composition of the coffee fruit during development and the variability of yield of individual bushes.

With the opening of the Sidapur Experiment Station it was possible to extend investigations on manuring, cultivation, and spraying, and the main results then obtained were summarized by Munro in 1926. The value of spraying was emphasized; manuring experiments gave much less definite results, but the value of green dressings and bulk composts was indicated. Some work on selection was started during this period, and the more promising seedling families were transferred to the Mysore Station.

The Mysore Coffee Experiment Station

In 1925 scientific work on coffee entered a new phase with the establishment of the Mysore Coffee Experiment Station. This Station has a total area of over 200 acres, of which about 80 acres are under old coffee, 20 acres under young coffee (mostly selections), and the remainder is still jungle reserved for future extensions. It has an excellent

laboratory, where plant-breeding, the study of diseases, and the preparation of samples for chemical analysis are carried out. The chemical control is carried out under the supervision of the Agricultural Chemist in the well-equipped departmental laboratories in Bangalore.

A most interesting feature of the work during the past six years has been the establishment of close co-operation of practically all the coffee-planting interests of South India in support of the work of the Station. The main budget of the Station is provided in equal parts from Mysore State funds and a small acreage cess on coffee land in the State. The United Planters' Association has provided the services of a European scientific officer and of an Indian assistant, an arrangement which has provided a most valuable addition to the staff of the Station. The interest of coffee-planters in general in the work of the Station has been further ensured and maintained by the establishment of an advisory committee of five coffee-planters, who are associated with the Director of Agriculture in Mysore in the supervision of the Station's work. This committee, consisting of representatives of the Indian and European planters of Mysore and of the United Planters' Association of Southern India, is calculated to keep the activities of the Station in close touch with the needs of the industry.

A general programme of work to extend over twenty years was laid down in 1928 and approved by Government; it should go far to ensure that continuity of effort without which the time and money devoted to research would largely be wasted. The programme envisaged the following chief lines of investigation:—

(*a*) *Chemical and soil investigations.*—These include a thorough study of the plant-food requirements of the coffee plant under South Indian conditions and a special investigation of the effects of soil acidity upon growth. Later on it is hoped to study the possible effect of manuring on coffee quality.

(*b*) *Plant diseases and insect pests.*—Plant diseases and insect pests have without doubt influenced the coffee industry of South India more than any other single set of factors. It was largely green bug (*Coccus viridis,* Green) and leaf-disease (*Hemileia vastatrix*) which led to the extensive abandonment of coffee cultivation in the Nilgiris towards the end of the nineteenth century, and mainly black rot (*Corticium koleroga*) which led to its abandonment in the western areas of Mysore and Coorg along the Western Ghats, and its replacement by cardamoms and, to a lesser extent, by tea. White borer (*Xylotrechus quadripes,* Chever) and leaf-disease have taken a heavy toll from coffee estates in the lower elevations of Mysore and South Coorg. More recently, dieback (*Colletotrichum coffeanum*) has greatly reduced crop-yields and weakened coffee plants over very large areas; and within the last two years it has been discovered that eel-worms are a very

serious source of failure and general unthriftiness of coffee in certain important districts.

(*c*) *Plant-breeding.*—This is perhaps the most important activity of the Coffee Station. Obviously, with a perennial crop like coffee progress must be slow, but an effort has been made to obtain results of practical value at the earliest possible moment by using material so abundantly available on coffee estates throughout South India and from other parts of the world. Associated with this breeding-work has been an investigation of the possibilities of using grafting methods for establishing selected strains of *arabica* coffee on more vigorous root-stocks, such as those derived from *C. robusta* and certain hybrids of *C. arabica* and *C. liberica,* which have been grown on a small scale for many years in Mysore. Although most attention has been given to the improvement of *C. arabica* by selection and hybridization, the fact that *C. robusta* is likely to be of increasing importance in the future has led to the development of selection work on this species also, whilst the presence in our extensive collections of promising races of *C. congensis* and *C. uganda* will allow for their early inclusion in our programme.

Review of Results so far Obtained

A period of eight years in the history of an Experiment Station dealing with a crop such as coffee is perhaps too short a time to warrant the expectation of results of striking value. However, the effects of the Station's activities are already widely apparent and some of the results obtained are undoubtedly of first-class importance.

(*a*) Although the results so far obtained on soils and manuring hardly warrant generalization on the manurial requirements of coffee in South India as a whole, yet they have largely revolutionized manurial practice. In so far as these results have shown returns from the manuring of coffee, they have indicated quite clearly the advantages of the use of concentrated artificial fertilizers, such as ammonium sulphate and super-phosphate, over the less concentrated organic fertilizers, such as oil-cakes and bone-meal, which were in almost universal use for coffee even ten years ago. The reduction in price of artificial fertilizers and the great saving in transport charges have had much to do with this change, but the evidence obtained at the Station that 'artificials' give better returns per fertilizer unit than the less concentrated organic forms has greatly influenced the change. Most of the manures now supplied conform with the formulæ worked out by Dr. Narasimha Iyengar, Agricultural Chemist, Mysore Agricultural Department, on the basis of his experimental work. The belief that organic fertilizers will have some special effect owing to their content of organic matter seems unfounded. The quantity of organic matter added in the comparatively small amounts

applied is infinitesimal in comparison with the amount yearly added to the soil through the fall of leaves from coffee plants and shade trees.

An interesting long-period experiment on the effect of pH reaction on the growth of coffee plants has already given clear indications that markedly acid or alkaline reactions in the soil are detrimental to the growth of coffee. This, along with the institution of pH determinations in the field by the chemical staff of the Department, has made much more definite the advice given to planters on the subject of liming.

(*b*) The investigation of plant-diseases and their control has given much more striking results. Long before the Station was established, one of the more important diseases, black rot, had been investigated by the author and his colleagues; its life-history and methods of spread had been worked out; and it had been established both by our own trials and by those of Frattini that the disease could be very readily controlled by spraying with Bordeaux mixture. Recently, the State Mycologist, Mr. M. J. Narasimhan, has cleared up a number of obscure points in connection with this disease. Although there was evidence that spraying with Bordeaux mixture would give an economic control of the more important leaf-disease, caused by *Hemileia vastatrix,* the course of the disease was not accurately known and the conditions governing the appearance of severe outbreaks were obscure. Mr. W. W. Mayne, Coffee Scientific Officer, was entrusted with an intensive study of this disease in October 1928, and the results he has obtained are of outstanding importance for the South Indian coffee industry.

In the first place, Mr. Mayne developed a technique for the statistical study of the incidence of leaf-disease throughout the year. His studies, which extended over two successive years, enabled him with some accuracy to deduce the climatic conditions, *i.e.,* atmospheric moisture and rainfall, that conduce every year to the serious increase in this disease, which is always present to a greater or less extent on every coffee estate in South India. There still remain to be investigated many of the environmental conditions favouring the spread of leaf-disease. One of the most important factors is undoubtedly temperature, for the study of cultures in the laboratory has already shown that temperatures below a certain minimum inhibit the formation of spores. Light has also been found to influence the germination of spores and the amount of spores developed, and hence also the establishment of fresh infections.

Perhaps the most striking result of Mr. Mayne's work on *Hemileia* has been the establishment of the existence of two physiological strains of this fungus. This discovery, which is of the greatest value in testing new *arabica* selections and new hybrids for resistance to leaf-disease, has at the same time dispelled obscurity concerning the resistance of the valuable selection Kent *arabica,* which has been widely planted during

the past ten years both in South India and in East Africa. This selection, which is due to the well-known Mysore coffee-planter, Mr. L. P. Kent, has been commonly found, particularly during the first two or three years of growth, more resistant to the attacks of *Hemileia vastatrix* than are the Coorg *arabica* types heretofore commonly grown, especially in Mysore and Coorg. This resistance has usually broken down later on, and for reasons that were quite obscure. Mr. Mayne has found that Kent *arabica* is highly resistant (one might say immune) to one of the two physiological strains so far isolated (strain No. 1), but highly susceptible to the other (strain No. 2). The usual Coorg *arabica* types are, on the other hand, susceptible to both strains.

In establishing and maintaining *Hemileia* strains in culture, recourse has been had to a technique originally developed by Clinton in America. It has been found that coffee-leaves, removed from the trees, can be kept alive in the laboratory for 6 weeks by immersing the petioles in tap-water contained in petri dishes, and this gives ample time, after inoculation with spores from a known source, for the development of pustules and a fresh crop of spores. This technique is now being used in the study of the resistance of coffee nursery plants to both the isolated strains of *Hemileia*. It has been found more satisfactory to leave the young plants in nursery for eighteen months rather than the usual 6–8 months, but the eventual saving of time and space will be enormous. Hereafter, only such selections as have shown themselves by this laboratory test to be resistant to the two *Hemileia* strains will be planted out in the field.

Space will only permit a passing reference to other serious diseases of coffee in South India, such as dieback and root-rot, with which are associated various fungi, the most important being *Fomes lamaoensis*. It must suffice to say that these are receiving continuous attention and that it is already fairly clear that dieback is susceptible to control by sprays used for controlling the two important diseases, black-rot and leaf-disease.

To the practical coffee-planter, the most important development in the control of coffee diseases has been the introduction of spraying, mainly against black-rot and leaf-disease, but also with considerable success against dieback.

The first spraying experiments were carried out by the Mysore Agricultural Department in 1911, and they were followed by those of Frattini in 1916–17 and those of Munro from 1922 to 1926. In addition, some Mysore coffee-planters carried out, at my instance, spraying tests on leaf-disease with a fair measure of success.

On the establishment of the Mysore Coffee Experiment Station, a very extensive series of spraying experiments was started dealing with the character of spray or dusting material to be used, the strength of

solution, the inclusion of adhesives of various kinds, the time and frequency of application, and the most suitable type of sprayers including knapsack-sprayers, hand-operated sprayers, working lines of hose, and motor-sprayers. It may now be considered as established that a thorough spraying with Bordeaux mixture (formula $2\frac{1}{2} : 2\frac{1}{2} : 50$) in the months of April and May, before the monsoon, ensures an almost complete control of black-rot. This application combined with a similar post-monsoon spray in October gives, in most cases, a satisfactory and economic control of leaf-disease and dieback. Where leaf-disease is serious these applications lead to the retention of double the amount of leaf, as compared with unsprayed coffee, and at the same time to an average increase in crop of about 2 cwt. of coffee per acre. With trained men and with thorough supervision over the preparation and application of the mixture, the two applications can be made at a cost of approximately Rs. 25 per acre. As even under present abnormal conditions the average price of coffee on the west coast of India is about Rs. 45 per cwt., it can be seen that spraying is likely to prove very profitable. This has been fully appreciated by planters, more especially in Mysore, where in 1933 nearly one-third of the total area (over 20,000 acres) was sprayed. Figures for areas sprayed outside Mysore are not available but they must amount to a further 10,000 acres. Thus we may take it that one-fifth of the total area under coffee is now being regularly sprayed for the control of important diseases. This is a development almost wholly confined to the past ten years, and it has played an important rôle in enabling Indian coffee-planters, more especially in the less-favoured areas, to withstand the very severe strain of the economic depression from which this crop, along with almost all others, has suffered in recent years.

Tests have not been confined to Bordeaux mixture, and, as a matter of fact, Burgundy mixture is fairly extensively used, more especially in areas where there are difficulties in obtaining satisfactory supplies of lime. However, careful tests conducted over a series of years at the Coffee Station show fairly conclusively that Burgundy mixture is not so effective as Bordeaux mixture. The experiments with other spray materials, *e.g.*, lime-sulphur, and with a large number of dust fungicides, have given very unsatisfactory results.

Spreaders and adhesives have been studied intensively, and although the results are not absolutely conclusive, the balance of evidence indicates that a spreader, such as lime caseinate or linseed oil, can be used with advantage. More recent trials with other vegetable oils as spreaders indicate that some of them are likely to prove quite as satisfactory as, and at the same time cheaper than, the two spreaders mentioned above, which are now in general use.

The small pressure-knapsack-sprayer, originally introduced into India over 25 years ago by the Mysore Agricultural Department and still generally used to control an important Phytophthora disease of areca-nut, has, for coffee-spraying, gradually been replaced by the so-called Headland type of sprayer, from which the spray material is pumped from a double pump, mounted on a skid, through long lines of hose (2 to 4 in number). Small motor-sprayers working on the same general principle as the Headland sprayers are used to some extent, but the high cost of petrol in India has militated seriously against their general adoption.

Turning to the insect pests of coffee, green bug (*Coccus viridis*) was very thoroughly investigated many years ago by Dr. K. Kunhi Kannan, late Entomologist to the Mysore Agricultural Department, and myself. Although it is still regarded as of considerable importance in restricted areas, it is, I think, not now generally considered a serious pest of coffee. Fairly effective control can be obtained by spraying with fish-oil and resin soap, according to a formula worked out by the Mysore Agricultural Department. Very recent work on insecticides by the Entomological Section of the Department has shown that fish-oil can be satisfactorily and economically replaced in the insecticidal soap by an oil expressed from the seeds of a common local leguminous tree, *Pongamia glabra*, and this is now being tested in the control of green bug and other sucking insects. Efforts to obtain a combined fungicidal and insecticidal spray to control this pest along with the main leaf-diseases have so far not been successful. 'Sulphemulsol', a proprietary product from Trinidad, is now under test.

White borer (*Xylotrechus quadripes*) remains the most serious pest of coffee over large areas. The most satisfactory method of control is, perhaps, the regulation of shade, for egg-laying is much more abundant in sunny than in shady areas, but coupled with this must go a thorough removal every year of bored trees. The application of ovicides and larvicides to the stem, and the scrubbing of stems to remove and destroy the eggs that are laid in crevices of the bark, have given results of some promise, but have not as yet been generally adopted. Lastly, the markedly greater retention of leaves in sprayed coffee, leading as it does to a much more effective shading of the stems, has appreciably reduced the damage done by this pest. This is an interesting case of control measures against fungous diseases proving fairly effective against a serious insect pest as well.

(*c*) *Plant-breeding.*—There has, of course, been a great deal of variety-testing and even of plant-breeding done by coffee-planters themselves, but, unfortunately, this work has with one or two exceptions left no permanent mark on the South Indian coffee industry, largely because

it was not carried out with adequate care or over a sufficiently long period.

The earliest type of *arabica* coffee grown in Mysore was, apparently, the so-called 'Chick' type (after Chikmagalur, an important town in the coffee district of North Mysore), characterized mainly by the growth-habit of the primaries, which rise at a rather acute angle from the stem. Opposed to this is the Coorg type, with primaries developed at almost right angles to the stem. Of these, the former has proved much more susceptible to leaf-disease than the latter and so has been replaced by it. Of the selections which are of the typical *arabica* type, only two have been cultivated at all generally, and of these the so-called Jackson *arabica* has not lived up to its early promise and has practically disappeared from cultivation. The other, known as 'Kent' *arabica,* developed by Mr. L. P. Kent of Doddengudde Estate, Mysore, has been very widely cultivated and is generally considered to be the best *arabica* strain now available in South India. As already pointed out, its resistance to leaf-disease is only partial; moreover, it cannot be said to be a uniform strain, as seed does not breed absolutely true. A very large number of rough selections has been made by individual planters and used for multiplication on their estates. Lastly, almost every estate has its representatives of the 'Golden Drop' and Maragogype types, which originated in Brazil, and of 'Blue Mountain' from Jamaica. None of these has, under South Indian conditions, proved as valuable a type as those which have been developed here.

There are a very large number of representatives of hybrids between *C. arabica* and *C. liberica.* In some cases these have originated as chance hybrids from seed picked from *arabica* bushes growing in the neighbourhood of *liberica* plants, of which there are considerable numbers scattered through the various coffee areas. Most of them, however, are the result of definite hybridization carried out by several planters, but chiefly by Mr. J. G. Hamilton of Chandrapore Estate, Mysore, and from them a large number of hybrids known as Netrakonda, Mockett's, Crawford's hybrids, etc., has arisen. These plants, which are usually characterized by great vegetative vigour and pronounced resistance to leaf-disease, show many other hybrid characters, *e.g.*, malformation of beans, marked deformity of the anthers, and even of the pistils. Most of them are comparatively poor bearers and nearly all show an abnormally high proportion of empty berries in the crop, the berries being in almost every case of the general *arabica* type. All of these hybrids are highly heterozygous and only a few have been taken up seriously as a plantation crop. Perhaps the most important of these is the so-called 'Netrakonda' hybrid, of which we have a comparatively large area on the Station, and

seed of which is regularly distributed by the owners of the Netrakonda estate.

Although, as stated, these hybrid types are generally of little value for plantation purposes, they form a rich mass of material for further breeding-work. A general collection of seed from the most promising of them was made in all the coffee areas of South India during the years 1927 to 1929, and the progeny now form an important part of the breeding-material in the Station. The availability of this valuable material should greatly shorten the task of evolving strains to suit our conditions.

C. robusta has been grown on a small scale in *arabica* plantations of South India for the past thirty years. There has been, therefore, ample opportunity for natural cross-fertilization to occur between these two species, but, nevertheless, no types have come to our attention which can indubitably be regarded as *arabica-robusta* hybrids. This is probably explained by the observation that where artificial cross-fertilization has been carried out, the F_1 generation shows morphological characters that are hardly distinguishable from those of the *arabica* parent. Similar results have been obtained in Java, where *arabica* has been used as the female parent, and so far this is the only cross we have been able to make. We have already accumulated a considerable amount of material of *arabica-robusta* hybrids, none of which shows particular promise. However, the F_2 generation may provide more promising material.

In addition to this interspecific-hybrid material, there are now available on the Station almost all the *arabica* types in cultivation, as well as the progeny of selected *arabica* trees growing on estates scattered over the whole of South India. Coffee-planters have co-operated generously in supplying the Station with this material, so I think we may safely say that our collection represents the best that South India has so far produced.

The purification of the material thus collected has formed one of the main items of work during the past five years. Within this time we have obtained one generation and are just planting out the second. The results indicate that a fair degree of purity may be expected within the next five or six years. Selfing in many hybrids has, owing to non-viability of pollen, been impossible, and where the plants have shown exceptionally good morphological characters cross-pollination has been resorted to, selected Kent *arabica* plants being used as the male parent. Our final aim must, of course, be to use homozygous material for crossing, but if we were to wait for this we should have to postpone all hybridization work for many years. It is expected that by using the large masses of admittedly heterozygous material now available on the Station, valuable strains of coffee will be obtained within a period of not

more than ten years. Our main object is, while retaining the high quality for which South Indian coffee is so well known, to develop high-yielding strains that will be much more vigorous and resistant to disease than those at present being grown.

A beginning has been made on the study of the inheritance of resistance to leaf-disease, which is so marked among many of the *liberica-arabica* crosses on the selection-plots of the Station. As already mentioned, the study of this disease led to the discovery of two distinct physiological strains of *Hemileia vastatrix* with which laboratory inoculation experiments on detached coffee-leaves were commenced. Working with the individual strains, a number of tests for susceptibility and resistance has been made on the parents and F_1 generation of some of the selections made at the Station. This work has not as yet proceeded very far, but the initial results indicate that disease-resistance is inherited along relatively simple Mendelian lines, with resistance dominant to susceptibility. It also appears that the factors of resistance to each strain of *Hemileia* are distinct, though probably not entirely independent. In one family there is strong evidence that resistance to strain No. 1 is inherited as a single factor.

This work is only in its early stages, but it holds out considerable promise for the future.

Experiments on grafting have been in progress for the past four years. A very large amount of valuable information has been collected which it is proposed to publish at an early date. Grafting has been successfully carried out through eight months of the year both in the nursery and in the field. *Robusta* seedlings have been used mainly as stock, and the scions have come from *arabica* trees selected for vigour and high yield. More recently we have used as stock, seedlings of the vigorous Netrakonda hybrid.

One of the main functions of field grafting would seem to be the establishment of selected *arabica* material on vigorous root-stocks in parts of estates where the growth of *arabica* plants is normally unsatisfactory. The results so far obtained in this connection are full of promise.

The replacement on estates of poor yielding but vigorous plants by stumping and then grafting scions from high-yielding plants on to developing suckers, has also been undertaken. This appears to be a most promising method of improving the population of coffee estates, but it will still be some years before definite results are available.

Another important function of coffee-grafting is multiplication of promising breeding-material. It is a general rule on the Station to multiply promising material in this way so that, should the parent tree die for any reason, it will not be lost.

It is fully realized that the use of seedling-stocks derived from heterozygous plants must result in variations in the grafted product.

Following the work at East Malling, experiments have been started on the vegetative reproduction of stocks, and the preliminary results are promising.

It is a matter for most profound regret that this essential scientific work for the improvement of the South Indian coffee industry was not started many years ago. As a matter of fact, I prepared plans for a Coffee Experiment Station as long ago as 1913, but the funds that were then set apart for this project had, in view of the Mysore Government of that time, to be devoted to other purposes. It is, however, a matter of most profound gratification to me that now, when I am breaking a connection of more than a quarter of a century with agricultural development work in India, I am able to leave behind me a well-organized, if small, Coffee Experiment Station, which I believe will play an important rôle in restoring the South Indian coffee industry to its former position of importance.

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The Cultivation of Tobacco with Particular Reference to Cigarette Tobacco and the Flue-Curing Process

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The following is an outline of the more important points in the cultivation of Tobacco in general but with special reference to Cigarette Tobacco and the Flue-Curing process:—

Classes and Varieties

Tobacco may be classified into three main classes:—

1. Cigar tobacco.
2. Manufacturing tobacco (pipe and cigarette).
3. Tobacco cultivated for the production of nicotine.

The cigar and manufacturing types of tobacco come under the species *Nicotiana tabacum*, whereas the third group belonging to the species *Nicotiana rustica* constitutes another class which is mainly grown for the production of nicotine and includes the Turkish tobaccos.

Cigarette Tobacco

The following types are all bright leaf cigarette tobaccos suitable for flue-curing and have been recommended for trial in Ceylon:—

1. Hickory Pryor.
2. Virginia Bright Leaf.

3. Jamaica.
4. White-Stem Orinoco.
5. Willow Leaf.
6. Bonanza.
7. Big Gem.
8. Harrisons Special.

The latter type has been tried in Ceylon and proved fairly satisfactory in the Kurunegala District during the 1933–34 season.

Soils and Climate

Tobacco is a crop that is very sensitive to environment (soil and atmosphere) which plays an important part in determining the type of tobacco to be grown, and the crop can only be grown in certain districts. Nearness to the sea is often a great drawback owing to the large amount of sodium chloride present which is reflected in the burning qualities and quantity of ash.

Generally speaking, a light sandy loam with a clay sub-soil is considered ideal for bright cigarette tobaccos, and the heavier types of soil for the dark and heavy-bodied pipe and cigar tobaccos. Sandy soils with a clay sub-soil will retain fertility better than a sandy soil with a non-clay sub-soil. A clay sub-soil is considered essential for the successful cultivation of tobacco in the United States, and a good sub-soil is said to improve the tobacco both as regards quality as well as colour. In all cases it is essential that the soil should be well drained.

Tobacco requires a moderate rainfall which should be fairly well distributed throughout the growing period and rather light during the maturing and harvesting periods.

Excessive rainfall, especially at harvest time, seriously affects the quality of the leaf, making it thin and deficient in gums, tends to make the midribs coarse, and also renders the crop more liable to spotting disease.

Planting out should be done in a season when the growing period could be completed in 5 to 6 weeks; and in tropical countries where two monsoons are experienced, the growing of tobacco should be restricted to the shortest monsoon period, say, a season of 3 months' rainfall. Where no such season is present the planting may be done to catch the late rains, thus allowing the crop to mature into the dry season.

Place in Rotation

Where tobacco is cultivated in rotation with other crops it would be well to remember that it should not follow a leguminous crop, as excessive nitrogen does not produce good cigarette tobacco, nor should tobacco follow another Solanaceous crop in the rotation. Tobacco may follow a cereal crop, specially if the land is subject to eelworm infestation, as nearly all cereals are immune to this pest; or tobacco may follow cotton.

Seed and Seed-Bearers

The proper treatment of seed-bearers is essential where a farmer intends to carry out his own seed selection for subsequent crops. When the plants in the field are ready for topping (*i.e.*, at the flowering stage) plants suitable for seed-bearers should be carefully selected and marked out. All side shoots with flowers are then removed, with the exception of three flower clusters at the top, giving a crow's foot appearance. Finally all the leaves below the crow's foot should be removed to a distance of eighteen inches to two feet. If the whole plant is allowed to go into seed the seed is apt to deteriorate. Where more than one variety of tobacco is being grown it is necessary to prevent cross-fertilization, and the selected seedheads should be bagged before the flowers open; and as the flower-stalks elongate, it will be necessary to raise the bag. (Any strong paper bag will answer this purpose.) The seed pods should be harvested as soon as they turn brown and be allowed to dry in a cool dry room. After this the plump pods should be selected and the seed shaken out by nipping off the tips. The seed is then dried in the cool, and stored in bottles until required. If imported seed is to be used, such seed should preferably be grown in seed plots in the first instance, and the seed thus procured from the first generation should be used for planting out the fields in the next season.

Nurseries

Nurseries should be established according to local conditions and should be well sheltered, well drained and accessible to water. As regards size of seed-bed required, a 100 square yards seed-bed will plant 5 acres of tobacco. Three beds each 1¼ yards wide and 27 yards long will provide the necessary requirements. The soil should be well stirred and then sterilized by burning some brushwood on the soil surface. The ash should be well incorporated into the soil. The seed-beds should not exceed 5 inches in height, and drains, 18 inches wide and 6 inches deep, should be provided between the beds.

Sowing Seed-Beds and Seed Requirements

Tobacco seed is exceedingly small, some 300,000 to 400,000 seeds going to an ounce, and when sowing, the seed should be mixed with some dry sand or ash so as to ensure even distribution. As regards the quantity of seed required, 1¼ heaped tablespoons of seed will be sufficient for sowing 100 square yards of seed-bed. All the seed-bed should not be sown at the same time, and it is best to sow at intervals of two weeks or so and to make 2–3 such sowings. The seed should be lightly broadcast and pressed down with a smoothing board and then watered. A watering can with a fine rose should be used. Covering or shading the seed-beds is not absolutely necessary, and in humid countries too much shading induces "damping off" disease and makes the seedlings leggy.

The seed-beds should however be sheltered from wind and heavy rain, and in the early stages the young seedlings may be shaded with cadjan thatch over a bamboo framework; and this shade should be gradually reduced as the seedlings get larger and stronger. The seeds should germinate in from a week to ten days.

Manuring the Seed-Bed

Two pounds of Nitrate of Soda well dissolved in 50 gallons of water make an excellent tonic for growing tobacco plants in the seed-bed. Sulphate of ammonia may be used in the same proportion, and is possibly the more preferable of the two as there will be less danger of scorching the leaves; and sulphate of ammonia does not leech so quickly from the soil as nitrate of soda. The latter is also apt to force the plants too much. If superphosphate is used, it should be applied before the sowing of the seed.

Preparation of Land for Planting

After the preliminary tillage operations such as, thorough ploughing and harrowing, have been completed and a good tilth obtained, the land should be ridged, the usual distance between the ridges being about 3 feet.

Manuring

Crops too highly manured with nitrogen do not produce good cigarette tobacco; and for this season, as stated earlier, leguminous crops in a rotation should never be followed by tobacco. A complete mixture containing 8 per cent. available phosphate, 3 per cent. available nitrogen and 5 per cent. available potash has been found satisfactory for tobacco. The fertilizer should be applied in the furrows 3–4 days before transplanting; the ridges are then split and the land left alone for 3–4 days. The last operation will produce a new set of ridges with the fertilizer below them.

Transplanting

Transplanting should be done when the plants are 6–9 weeks old and not later than 9 weeks as by then the stems are usually too hard, and such plants fail to form a good root system. A good test to ascertain whether the plants in the nursery beds are suitable for transplanting is to take up a plant which is about 6 inches high, and to bend the root ½ an inch from the tip. If the root snaps, the plant is of a suitable age for transplanting, but if on the other hand the root just bends, the plant is considered too old and unsuitable.

Short stocky plants are better for transplanting than leggy ones. Transplanting is best done on a cloudy day if possible. If the nursery beds are dry at the time of transplanting, they should be thoroughly watered before the plants are removed.

At the time of transplanting the marker should be set at the correct distance of planting (*i.e.*, distance between the plants in the row) and driven across the ridged land. When planting out a depression is first made on the ridge where the marker has intersected it by pressing down the soil. The hole for inserting the plant is made in the depression, and the plant is then carefully inserted and watered immediately. Finally, the hole is closed up. It is desirable in planting to have the fertilizer about 4 inches below the plant, and by planting out in a depression made on the ridge as indicated above, the roots of the plant are brought within the required distance from the fertilizer. It is a sound practice when planting to bend over one of the leaves of the plant so as to cover the bud and to place a clod of earth on it to retain it in position. This will prevent the bud from drying off during the first few days after transplanting.

Planting Distances

High quality leaf requires close planting between plants and rather wider spacing between the rows. Some common distances of planting tobacco are:—

(*a*) 2 feet between rows, plants 2 feet apart.
(*b*) 3 feet between rows, plants 1½ feet apart.
(*c*) 3 feet between rows, plants 2 feet apart.
(*d*) 4 feet between rows, plants 20 inches apart.
(*e*) 4 feet between rows, plants 2 feet apart.

Inter-Cultivation and After-Treatment

Surface cultivation between the rows after each rain is ideal. In practice, however, several surface cultivations should be given during the growing period so long as this operation could be safely carried out without causing injury to the plants, and should cease when the plants are ready for topping.

Priming

When the plants are about 18 inches to 2 feet high, it is usual to go round and remove the sand leaves and some of the bottom leaves up to a height of about 6 inches from the ground. These leaves are of little value, and usually harbour the spores of Frog Spot Disease of tobacco. Priming, therefore, reduces spotting by the removal of disease-affected leaves, and also promotes aeration of the plant. All primed leaves should be collected and burnt.

Topping

The plants are said to be ready for topping when they have reached the flowering stage, and possess at least 8–10 good leaves. It is difficult to lay down a hard and fast rule with regard to topping, but generally speaking, vigorously and healthily growing plants should not be topped

at all; but if topped, however, the suckers which grow from the leaf axils should be allowed to remain. Plants selected for seed-bearers are never topped. All poorly growing plants should be topped, usually at a height where the leaves are 5 inches broad. In the latter case, all suckers should be systematically removed. The leaves are ready for harvesting from about 4–6 weeks after topping.

Pests and Diseases

Tobacco is subject to a number of pests and diseases, but only a few of the troubles commonly met with in Ceylon are mentioned in this article. The control measures and spray formulæ suggested under diseases are those recommended by the Mycological Section of the Department of Agriculture, Ceylon.

Pests: Stem-Borer

The presence of stem-borer in the field could be often detected by the poor growth of the plants, and in advanced cases by a wrinkled appearance of the leaf bases. On splitting open the stem, the borer could be seen tunnelling within. Where the pest is bad, measures to check its attack should be taken in hand from a very young age, and consist of the cutting off of all apparently affected low leaves, leaving one or more of the sound suckers to shoot out and produce a fresh plant. All infected material thus cut should be collected, removed from the field and burnt. In the case of severe infestations it would be a sound farming practice to remove and burn all tobacco stubble after harvest instead of ploughing such material into the land.

Diseases

1. *Frog-Eye Disease of Tobacco* (Cercospora nicotianæ).—This is a fungus disease causing the spotting of the leaves. The disease is not so important in the case of chewing tobacco as it is on cigar and cigarette tobaccos. The disease occurs on the oldest leaves. Infection is brought about by spores of the fungus falling on the leaves. The spores can germinate in 2 hours and infect the leaf. A week or so later the spots begin to appear, and 1–2 weeks after that, depending on the weather, spores are formed, and in this way the disease can spread throughout the entire crop. As regards control, over-crowding and excessive moisture should be avoided; the early priming of the sand leaves and lower leaves upto a height of about 6 inches from the ground when the plants are young and about 18 inches to 2 feet high, will diminish infection considerably. The removal and burning of all infected stubble after harvest is recommended, as this stubble is likely to form a source of new infection.

2. *Bacterial Wilt of Tobacco.*—This disease can be recognized in the field by the wilted appearance of the plant, and by discolouration of

the vascular tissue visible when the stem is split open. The disease is due to bacterial infection from the soil, and the bacteria responsible can only enter the plant through broken or wounded roots. As regards control measures avoid damaging the roots as much as possible in transplanting and by careless intercultivation. The control of Stem-Borer and Eelworm will help in controlling Wilt disease, as healthy plants are less liable to attack. Liming should not be done when this disease occurs as alkaline conditions are said to favour the disease; on the other hand, manures that tend to make the soil acid are said to check the disease. All diseased plants should be uprooted and burnt as soon as they are discovered.

3. *Mosaic Disease.*—This disease is classified as virus disease, and may be identified in the field by the mottled appearance of the leaves and the darkening of the veins when the leaf is held up to the sun. The sap of the diseased plant is highly infectious. "Frenching" is the name given to a type of Mosaic where the leaves become long and thin. In the case of young plants immediate control measures are necessary, as the disease can be carried by hand as well as insects. All infected plants should be pulled out and burnt as soon as detected.

4. *Eelworm.*—Eelworm attack very often depends on the previous crop grown on the land. Nearly all cereals are found to be immune to eelworm, and, therefore, where land is subject to eelworm tobacco should always follow a cereal in the rotation. The practice of a bare fallow turned over periodically is also recommended as a control measure.

General Control Measures against Tobacco Diseases

1. *Seed.*—The spores of the Frog-Eye disease of tobacco often adhere to the seed capsules and ultimately get mixed with the seed. Hence, seed treatment becomes necessary which consists of putting the seed in a muslin bag and soaking it in a solution of silver nitrate of the following strength:—9 grains silver nitrate to 1 pint of water. The seed should be soaked in this solution for 15 minutes, and then taken out and washed in six changes of running water. The treatment here recommended will kill all spores mixed up with the seed.

2. *Seed-Bed.*—The selection and preparation of the seed-bed is very important from the point of view of disease control. The same seed-beds should not be used over and over again. The seed-bed should be sterilized by the burning of dry vegetable trash on the soil surface, and this will kill out such troubles as eelworm and *Rhizoctonia solani* ("damping off" disease). The seed-beds should be raised so as to afford adequate drainage.

3. *Seedlings* (*Nursery Diseases*).—Nursery plants 2–3 weeks old should be sprayed every week or 10 days as a measure of control

against Frog-Eye Disease. The spraying should be started before any signs of the disease appear.

The following sprays are recommended:—

(*a*) *Bordeaux Mixture.*—2 lbs. Copper Sulphate, 2 lbs. Lime and 40 gallons water.

(*b*) *Bouisol.*—½ oz. to 1 oz. Bouisol (fluid) to 1 gallon of water.

1 oz. of soft soap should be added to every 2 gallons of the spray as a sticker. The latter spray will also help in checking "damping off" disease of seedlings. Where the disease is severe, it appears in patches in the nursery and in such cases every affected plant should be removed, and the patch freely watered with a solution of Jeyes' Fluid—1 oz. of the fluid to 1 gallon of water.

4. *Transplanted Plants.*—Spraying is not practicable in the field, and all plants showing any signs of disease should be uprooted and burnt.

5. *Harvesting.*—The crop is ready for harvesting 60–70 days after transplanting, and when the leaves gradually turn from deep green to a yellowish green shade similar to the colour of a lemon when it is ready for picking. The whole plant may be harvested or single leaves picked as they mature. The latter system is preferable in the case of flue-cured tobaccos. Picking is done by hand and should be carried out every 5–6 days or once a week, depending on the barn arrangements. A single picking over a 5-acre field will fill a 16 ft. by 16 ft. barn.

Leaves must, if possible, be harvested before any spotting appears, and badly spotted leaves should not be harvested. Green leaves or leaves showing vigorous growth such as appear on plants growing on ant hill, or leaves of plants too highly manured with nitrogen, should not be harvested for flue-curing as they will not produce a good cigarette tobacco. The presence of gum on the leaves at harvest is essential, and it is, therefore, inadvisable to commence harvesting immediately after rain or on a day following heavy rain. Harvesting should be done in the morning when the dew is still on the leaves. The harvested leaves should be removed to the barns as soon as possible, and should never be allowed to remain exposed to hot sun for any length of time. If it becomes necessary to allow the leaves to remain in the field for some time, it is advisable to harvest with a small piece of stem attached which will help in preventing the leaves from wilting too much. Bruising or in any way damaging the leaves during the harvest and subsequent handling should be avoided. Some sort of long basket might be used in the field for collecting and transporting the harvested leaves to the barn.

II

Flue-Curing of Tobacco

1. *Flue-Barns: Their Dimensions and Construction.*—Special curing facilities such as Flue-Barns are required in the production of high quality bright leaf cigarette tobacco.

A popular size of flue-barn suitable for the flue-curing of tobacco has the following dimensions: 16 feet long, 16 feet broad and 19 feet high with a single furnace. Other favoured barn sizes are 12 feet by 16 feet with single furnace; 16 feet by 20 feet or 20 feet by 20 feet, or 20 feet by 24 feet, with double furnaces. The material used for constructing the walls and roof of the barn may be mud and wattle, mud and poles, mud and cocoanut or arecanut logs or asbestos sheeting. A double roof is not essential. It is not intended to go into the detailed structure of a suitable barn here. This is a subject by itself upon which help can be obtained from the Agricultural Department. The essentials are the room or barn, with a furnace for heating the same.

Tiers of poles are arranged within the barn for holding the sticks on which the tobacco leaves are strung. Vertically the first tier should be 7 feet above the ground level and each successive tier 2 feet above the last; and horizontally the tiers should be 4 feet apart. A space of 2 feet 6 inches should be left between the topmost tiers and the roof of the barn. The sticks for stringing the leaves are 4 feet 6 inches long and are arranged 8 inches apart on the tiers.

2. *Preparation of the Leaves for Flue-Curing.*—In harvesting tobacco for flue-curing, it should be remembered that the bottom leaves are the easiest to cure from a cigarette point of view; the leaves higher up the plant have more body and are, therefore, more difficult to cure; and the tip leaves are most difficult to flue-cure. As soon as the harvested leaves have been transported to the barn, they are carefully strung up on sticks 4 feet 6 inches long. The leaves are tied on in bunches of three alternately on either side of the stick. The leaves should be arranged so as to have the backs of their midribs touching one another. The leaves when held in the bunch should present a triangular appearance. There should be 28–30 bunches of leaves per stick (*i.e.*, 14–15 bunches on each side). During this operation, any leaves unsuitable for flue-curing should be discarded. As each stick is completed, it should be packed into the barn and arranged on the tiers, the distance between the sticks being 8 inches. A golden rule in flue-curing is to take particular care to see that the barn is completely filled before commencing to cure. When the barn is filled, then the curing process is started by raising the temperature inside by means of the furnace.

3. *The Curing Processes*: (*a*) *Yellowing Stage* (80–90°F).—When the leaves are well ripe, the yellowing stage of the leaf takes

18–24 hours to be reached; if green, this stage may take as much as from 30–40 hours. There is no harm if the temperature rises to 100°F., but it is best maintained at 90°F. until the yellowing is complete. The leaves should not be allowed to get too yellow before commencing to "fix the colour". It is better to err on the green side, and any such green colour will disappear during the later stages of curing. Yellowing at 90°F. should be continued until as much of the leaves as possible have attained the right colour. During the yellowing stage all ventilators should be kept closed.

(*b*) *Fixing Stage* (100–110°F.).—As soon as the leaves have become sufficiently yellow, the next stage of fixing the colour should be commenced. Allow the temperature to raise gradually from 90°F–100°F. and then half open the top ventilator. Then the temperature is raised at the rate of 2½° per hour until 110°F. is reached, when the fixing period ends. At 102.5°F., the bottom ventilators should be opened a couple of inches or so; at 105°F., the top ventilators should be fully opened and the bottom ventilators half open; and at 107.5°F., the bottom ventilators should be fully opened.

(*c*) *Drying the Web of the Leaf* (110–140°F.).—The most critical period in flue-curing is from 110°F., to 120°F. The temperature should be raised from 110°F. to 125°F., in stages of 2.5°F., per hour. During this stage, the temperature on no account should be allowed to fall, else the tobacco will "sponge" badly. (Sponging is due to the failure to get rid of the moisture on the leaf as quickly as possible.) In order to get the leaf accustomed to high temperatures, it is a sound flue-curing practice to maintain the temperature at 125°F. for 2–3 hours and then proceed to 130°F., when no further rise in temperature should be made until the web of the leaf is two-third dry. Then proceed to increase the temperature in stages of 3–5 degrees per hour until 140°F. is reached, and complete the drying of the web of the leaf at this temperature. The top and bottom ventilators are fully open during this stage of curing.

(*d*) *Drying of Midrib* (140–165°F.).—When the web of the leaf is dry, the temperature should be raised by 5 degrees stages. At 145°F., the bottom ventilators should be partly closed, and at 155°F., all ventilators should be fully closed. In new barns, a decidedly foul smell of the tobacco may be noticed at the first curing due to moisture in the walls of the barn; if this be the case, the top ventilator should be opened for an hour or so to allow the foul air to pass out. The temperature, on reaching 165°F., should be maintained at that until the leaf and midrib are dry. The fire is then drawn or allowed to die down. All ventilators and doors should be opened and the barn allowed to cool down. At 165°F., the leaves are very brittle and the aroma inside the barn resemble that of a biscuit factory.

4. *Shingling.*—When a good cure results, the leaves should be yellow and the midribs should snap with a crack when bent, but the leaves, however, should not split. The leaves should be slightly flaccid before they are removed from the barn, but not too much. After the barn has cooled down sufficiently, and when the leaves could be handled without damaging, the sticks are carefully removed with the leaves still attached and arranged on the floor on newspapers in a dry room. The sticks should be so placed that one stick will overlap one-third the leaves of the previous stick. In this manner the tobacco is piled up into a neat heap which is covered over with some hessian or mats and left for some days, particularly if the weather conditions happen to be too humid and rainy. If the leaves are removed from the sticks under such conditions, they are apt to become moist and will be difficult to dry again. The colour will also be affected. The process of removal of the leaves from the barn and storing as described above is known as "shingling". Under favourable weather conditions, the leaves could be detached from the sticks even on the day following the shingling.

5. *Condition of Leaf.*—The leaf should be sufficiently damp so as to be pliable and not break in handling. On the other hand, the leaf should never be wet or too soft. If the leaf should become too soft, it should be dried out by hanging in the shade exposed to the air until sufficient moisture has gone out of the leaf so as to leave it in proper condition for grading and bulking. If a number of leaves is gathered together in the hand by grasping the butts of the leaves and these are then shaken out and held upright and if the leaves remain more or less erect, it is a rough indication that the tobacco is in a safe keeping condition; if, on the other hand, the leaves droop like the leaves of a palm, it is unsafe to handle the tobacco. Again, if the tobacco is in proper condition, the midrib will easily break when held between the thumb and forefinger. If the midrib is soft and pliant, usually the leaf is in an unsafe keeping condition.

In case the tobacco has to be transported prior to grading, the leaves should be carefully removed from the sticks and packed into a baling press of the following dimensions:—24 inches wide, 34 inches long and 18 inches deep.

The leaves must not be packed too tightly. The bale should weigh about 150 lbs. and not more. A baling box, 36 inches high, with the other internal dimensions stated above will give a bale of tobacco weighing approximately 150 lbs. provided the box is loosely filled. The bale should be wrapped in hessian or dry matting to prevent undue drying and damage by handling.

6. *Grading.*—Grading performs two important functions:—

(*a*) It allows the tobacco to show up in the best light and so

affords the grower a better chance for bargaining with the prospective buyer.

(*b*) It gives the grower as well as the prospective buyer a more or less correct idea as to the percentage of the various grades.

In the case of cigarette tobacco, colour is the sole criterion or guide upon which to grade. After grading according to colour, it is usual, from the point of view of quality, to make different grades of the same colour.

A greenish tinge (*i.e.*, a yellow leaf with a greenish tinge near the veins) to bright cigarette tobacco is desirable for the following reasons, *viz.*, it is often necessary to keep the cured leaf 5–8 weeks before it can be marketed; and during this time should the leaf become too moist, a loss of colour will result. When a greenish tinge is present, this loss of colour is less, and the change that takes place will be a loss of the greenish tinge in the leaf resulting in a brighter leaf than would be the case had the tobacco been cured without the greenish tinge.

Flue-cured tobacco is usually graded as follows:—

Grade I.—Bright lemon coloured leaf.

Grade II.—Bright orange coloured leaf, but not so clear as Grade I. This Grade will include slightly sponged or blotched leaves, but should show good colour.

Grade III.—Leaves with a fair amount of colour but not good enough for inclusion in Grades I or II. These leaves could carry a trace of green.

Grade IV.—Carries the bright green leaves which should be free of serious sponging. These leaves, if kept in proper condition, will after a few weeks improve in colour considerably and can then be regraded into Grades I and II.

Grade V.—Consists of all leaves that cannot be included in the above 4 grades. The leaves in this grade will show very little colour and will carry sponged and dark leaf. All dead and perished leaves should be discarded (*i.e.*, leaves with no stretch).

Grade VI.—Into this grade will be put all dark brown and deep green leaves which are unsaleable from a cigarette point of view. If the picking and curing have been properly done, there will be no need for this grade.

7. *Bulking.*—After grading, the leaves in each grade are made into small hands of 18–30 leaves depending on the size of the leaves. One of the leaves should be used for tying together the leaves of a hand. The various grades are kept separately in a single bulk, the division between the grades being maintained by pieces of string.

The buyer usually re-dries the tobacco either by special machinery or in specially constructed rooms with steam coils. When the leaf is quite dry, it is reconditioned by the manufacturer by putting back a certain amount of moisture, varying in amount from 10 per cent. to about 13 per cent., to suit the special requirements of the various grades.

The tobacco is finally kept by the manufacturer and allowed to mature for a period of 2–2½ years when it is ready for the manufacturers' purposes.

8. *Yield.*—1 acre of tobacco should yield about 750 lbs. of cured leaf.

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